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# Paper Pulp from Australian Timbers.

*By L. R. Benjamin, Officer-in-Charge of the Council's Paper Pulp Investigations.*

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## 1. General.

The manufacture of paper is an industry that has always followed closely upon the settlement of new territory by English-speaking people, and Australia presents no exception in this respect. The first paper mill in this country was established on the Barwon River at Geelong, in Victoria, some 50 years ago. At that time, and for a considerable period subsequently, the principal raw materials were rags, waste paper, and straw. At this mill newsprint was regularly made from straw for many years for one of the leading Melbourne dailies, but the output was small, and as soon as wood-pulp became available, the high cost of producing straw paper brought about a cessation of its production and a concentration on the manufacture of other kinds of paper. Straw was thus the only local raw material used in the industry in Australia 50 years ago. Curiously enough it is the only one used to-day, fairly large quantities being converted into one of the coarsest of papers made, viz., strawboard.

During the period in which the paper industry in Australia was slowly growing, enormous expansion took place in other parts of the world, principally in those countries where abundant supplies of softwood were available, as in the United States of America, Scandinavia, and Canada, or where the conditions were favorable for transportation of the products arising from the conversion of such softwood, as for instance, from Norway and Sweden to England and the Continent. The first important phase of this great expansion in papermaking followed the production of groundwood or mechanical pulp, the use of which permitted the manufacture of paper at very much lower prices than was previously possible. The impetus given the industry by this innovation, however, soon slackened, because the new product required the addition of a proportion of long-fibred pulp, the only source of which at that time was cotton and linen rags. Then came the chemical process of converting wood to pulp—known as the sulphite process—and with its advent the foundations were laid of two

industries which stand out as among the most remarkable of this century, viz., newsprint and artificial silk. Great as was the expansion of the newsprint industry immediately following the production of long-fibred pulp from coniferous wood, it now appears almost negligible compared with the amazing growth of this industry in the past ten years—a growth which has been due to the huge circulation of newspapers and to the introduction of advertising on a scale hitherto inconceivable.

During all this time there was but tardy development in the paper industry of Australia. In the last twenty years, for example, only two new mills have been established, and both are board mills. There was some expansion in the wrapping-paper industry in that period, and further development in this direction is now proceeding. We make in Australia most of the paper board used, and the mills have the capacity for making it all; we will soon be in a position where nearly all the wrapping paper can be made in local mills, but outside these the production of other grades is very small and in some grades entirely absent, e.g., newsprint. Nevertheless, all the paper and board (excepting strawboard) made in Australia at present is produced from pulp imported as such, or in the form of paper which finds its way to the mills as waste in one condition or another. The principal reason for the tardy development of the Australian industry in its various branches is, therefore, fairly obvious, viz., the absence of an indigenous raw material capable of conversion into pulp possessing the properties of the "half-stuffs" imported from abroad and generally used throughout the world. Had such raw material, e.g., coniferous wood, been available in Australia, it is safe to say that we should have seen the pulping industry established 30 years ago, and with it the expansion of the paper industry on a scale commensurate with our requirements. Further, had it not been for the well known fact that there is a danger of supplies of softwood abroad being insufficient to meet the demand in the comparatively near future, it is unlikely that we should have found it expedient to explore the possibilities of converting indigenous raw materials into pulp, and of growing exotic conifers for a similar purpose.

Actually the first movement directed towards an investigation of the suitability of indigenous raw materials for paper pulp was caused by the unsatisfactory condition that developed in Australia during the war and immediately after. Supplies of paper became scarce, and exceedingly high prices had to be paid for the material made available from abroad. At this time publishers in Australia were particularly harassed and entirely at the mercy of foreign paper sellers. As much as £85 per ton had to be paid for newsprint which three or four years before had cost £13 per ton. Several other grades of paper not made in Australia also reached very high price levels, so that there was wide support for a movement towards ascertaining the possibilities of utilizing our own raw materials for paper-making. Committees were formed in New South Wales and Victoria, and were instrumental in having certain experiments carried out both locally and abroad, but no systematic attack was made on the problem until the matter was taken up in 1918 by the then newly formed Advisory Council of Science and Industry. The co-operation of foresters and chemists was then effected, and preliminary experiments were made in the direction of converting eucalypts into paper pulp and of utilizing other indigenous raw materials such as grasses and sedges. This

work was started in Western Australia in 1918, and it is very largely due to the energy and enthusiasm displayed by those who initiated it and inspired confidence in the possibilities of utilizing Australian eucalypts, that the investigations have proceeded with vigour and attained a measure of success which warrants the expression of opinion that the foundations of the pulping industry are now laid. The investigation in its earliest stages was under the direction of I. H. Boas, M.Sc., then lecturer in chemistry at the Technical School, Perth, Western Australia. The splendid co-operation of the Forestry Department under C. E. Lane-Poole, the moral and financial support of the daily press in Western Australia and the general public interest in the work, combined to give an impetus to an investigation that soon spread beyond the borders of the State and, when in 1920 the Institute of Science and Industry authorized the establishment of a temporary Forests Products Laboratory at Perth, ultimately embraced a systematic survey of the whole Commonwealth. Though, for various reasons the Laboratory did not expand, the pulp and paper investigation continued along the lines laid down at the outset and the series of projects then formulated has now been largely carried out.

The investigation was planned to embrace the following:—

*Project A. Chemical Pulp.*

1.—Soda Process.

(*a*) Eucalypts.
(*b*) Other indigenous timbers.
(*c*) Grasses, sedges, etc.
(*d*) Exotic conifers.

2.—Sulphate Process.

(*a*) Eucalypts.
(*b*) Other indigenous timbers.
(*c*) Exotic conifers.

3.—Sulphite Process.

(*a*) Eucalypts.
(*b*) Exotic conifers.

*Project B. Mechanical Pulp.*

Grinding properties of immature eucalypts.

In addition to the above projects, other lines of investigation have been followed from time to time and semi-commercial scale experiments have been conducted as the occasion required.

## 2. Soda Pulp.

(*a*) *From Eucalypts.*—For example, after two years' investigation of the application of the soda process to the pulping of the eucalypts, the results were considered to be sufficiently encouraging to warrant the study of the production of pulp on a semi-commercial scale and its conversion into paper. Here the objective was the manufacture of printing papers other than newsprint, e.g., book and magazine paper. The laboratory pulping and paper-making experiments had shown that the principal eucalypts could be satisfactorily converted into paper of these grades, provided certain modifications of cooking procedure were followed and appropriate treatment was given the pulp in the beaters. It was found, for example, that a relatively low concentration of active alkali in the cooking liquor was necessary to attain

maximum strength, bleachability and high yield; and that mild treatment of the fibre when under preparation in the beaters would give paper possessing excellent strength and finish. These results were repeated when large scale tests were made in a commercial paper mill* in Victoria in 1922-1923. Thus, where the regular cooking methods failed to produce satisfactory pulp from the wood, and the customary paper mill practice spoilt the fibre for paper-making, by suitable modification of each, the eucalypt was shown to be a useful substitute for other woods pulped by this process and used in the manufacture of that important range of papers generally classed as "book and fine printings."

(*b*) *From Woods other than Eucalypts.*—Investigations carried out on other woods gave results often differing from those obtained with the eucalypts. Most of the these other species were from the rain forests of Queensland and Northern New South Wales, and they were representative of an entirely different type of timber from the eucalypt. For the most part they are softer, have a much more distinct medullary ray system, and many do not grow into large trees. On the whole, they give rise to a less easily bleachable pulp than the light coloured eucalypts of south-east Australia (Victoria, Tasmania, and Southern New South Wales), but on the other hand most of them are somewhat longer-fibred, the relative averages being about 1.35 mm. to 1.1 mm. for the eucalypts. The longest fibred of these woods is candlenut (*Aleurites moluccana*) from North Queensland, and this species also shows a higher cellulose content than any other Australian wood (62%). It is also relatively easily bleached, as would be expected from the high cellulose value. From a commercial point of view it is probably the best of all the tropical woods for pulping purposes, as it also grows at a phenomenal rate into a comparatively large tree.

The conclusion reached in regard to the woods from these forests (brush-woods or scrub-woods) is that they would be more suitable for use in admixture with longer fibre for the manufacture of brown (kraft) wrapping papers, than for the production of bleached pulp. The forests in which they occur, are generally very much more mixed and slower growing than southern eucalypt forests, and for the most part they occur as patches of relatively small extent surrounded by eucalypt forest containing species not particularly suitable for pulping. Their utilization accordingly offers much less attraction to the pulp-maker than the gregarious forests typified by stringybark (*E. obliqua*), mountain ash (*E. regnans*), &c., of the South-East and of Tasmania.

Curiously enough these northern forests contain species possessing fibre characteristics similar to the regular coniferous pulp-woods. Thus hoop pine and bunya pine (*Araucaria Bidwillii* and *A. Cunninghamii*) resemble the true pines but are longer fibred. They occur, however, in very limited extent and are too valuable for other purposes for consideration as a source of commercial pulp. The only other indigenous species possessing long fibres are the so-called cypresses (*Callitris sp.*) and a Queensland kauri (*Agathus sp.*) neither being of any importance from the pulping point of view.

* Kindly made available at Geelong by the Australasian Paper and Pulp Co. Ltd.

(*c*) *From Grasses, Sedges, Etc.*—In the earlier period of the investigation a number of sedges and a few grasses were examined. The best pulp from this class of raw material was obtained from some of the Gahnias, or "cutting-grasses," and it closely resembled the product obtained from the well-known esparto grass so extensively used in the manufacture of first-class printing papers in the United Kingdom and France. The various species of *Scirpus* are generally unsuitable on account of their black spikes and seed heads which contaminate the pulp and spoil it entirely for white papers. Some of the reeds proved interesting in that the fibre length was equal to that of the standard pulp-wood, spruce. The pulp yield, however, is almost always low—less than 30% of the dry fibre—and trouble is experienced in removing the residual pith.

It soon became evident that on the whole there was little prospect of developing a branch of the pulping industry on indigenous grasses and the like, for apart from the cost of collecting the material, the areas were scattered and relatively small.

(*d*) *From Exotic Conifers.*—Considerable experimental work was done during 1922 on the pulping of exotic conifers, principally *P. insignis,* a timber that has been and is still being planted extensively in most of the States. Preliminary examination of this wood revealed the fact that it possessed a fibre resembling spruce rather closely, and as it possessed the decided advantage of rapid growth, the conclusion reached was that a thorough study of its pulping properties was warranted. Much useful data were obtained during the pulping of this wood by the soda process, but it was found that while strong pulp suitable for wrapping (kraft) paper could be obtained readily, it was practically impossible to convert this wood into bleachable pulp economically and by ordinary means. This difficulty was finally overcome by producing mildly cooked strong brown pulp and removing the comparatively large amount of residual lignin with chlorine water of the proper concentration, subsequently brightening up the pulp with a very weak hypochlorite bleach. The colour thus obtained is almost equal to regular bleached sulphate pulp, the yield is high, and the product strong. It seems likely that a new grade of pulp requiring little beating could be produced in this way. Where electrolytic soda and chlorine production is economically feasible in conjunction with the operation of soda pulping there is little doubt that *P. insignis* could be converted into a pulp of high grade.

### 3. The Sulphate Process and Pinus Insignis.

This method of producing pulp is not as attractive in Australia from an economic point of view as in other countries where salt cake affords a comparatively cheap source of alkali. Nevertheless, it presents other advantages which may render its adoption expedient. Actually the sodium sulphate used in this process is reduced to sulphide by calcining with organic matter dissolved from the wood during cooking. The sulphate is merely added to the spent liquor in the alkali recovery plant where, after evaporation, calcining, and smelting, it enters the system as sodium sulphide, the concentration of sulphide seldom rising above about 35% of the total active alkali in the cooking liquor. The process is therefore essentially the same as the soda process in which caustic soda is the active re-agent. For the same concentration of total active alkali, however, the solution

containing the sulphide gives rise to a stronger pulp and a slightly higher yield, an interesting effect apparently caused by the depression of the hydrolysis of sodium sulphide through high concentration of caustic soda.

It is by this process that the great bulk of strong (kraft) pulp is produced. Its effect on the pulping of the eucalypts was not found to be very pronounced. It proved useful in pulping brush-woods and the like, but is of most importance in the making of kraft pulp from *Pinus insignis.* Laboratory experiments showed that the use of sulphide in the cook liquors raised the strength of the pulp 20% to 30% and the yield 5% or 6%, as compared with straight caustic soda pulping. This laboratory work has just recently been confirmed on a mill scale in New South Wales, where a kraft pulping plant was installed* by the Council for Scientific and Industrial Research in conjunction with the Development and Migration Commission to determine the value of *P. insignis* as a raw material for the manufacture of kraft pulp. It is now certain as a result of this work that *P. insignis* can be placed in the same category as spruce and fir as a pulp-wood for use in the kraft paper industry. This information should prove of immense value to the Australian States planting this pine on an extensive scale. In South Australia, for instance, it means that twelve or thirteen years hence, all the kraft pulp used in the country could be produced from this pine, thus assuring a market for some of the timber now being planted, and affording an outlet for thinnings from areas being managed for the production of mill timber. As there is already sufficient timber available for operating a commercial pulping plant, and the district in which the pine plantations have been formed is well watered and supplied with the limestone required for the process, it seems likely that the industry will be established in the near future. In fifteen years, the yield of timber per acre averages 30 cords, equal to 15.5 tons of pulp, and as the Government programme provides for the planting of 5,000 acres annually, two seasons' work having already been accomplished on these lines, thirteen years hence it would be possible to produce 75,000 tons of pulp annually, worth over £1,000,000. With the ever increasing use of kraft paper in new directions, the whole of this pulp might be converted into that class of product, but even if it were not, there would be ample scope for its disposal in other forms.

## 4. Sulphite Pulp.

(*a*) *From Eucalypts.*—By far the greater part of the chemical pulp manufactured from wood is made by the sulphite process. This process differs from the other chemical processes in that an acid cooking liquor is employed, and, whereas the alkaline processes use higher pressures of from 100 to 125 lb. per square inch and corresponding higher steam temperatures, the sulphite process operates with larger digesters, lower pressures (maximum 80 lb. per square inch), and relatively low temperatures. The cooking liquor is an acid bisulphite produced by the inter-action of sulphur dioxide with limestone or lime and water. There is always a large excess of sulphur dioxide in solution beyond that required for combination with calcium oxide to form the bisulphite, and while the re-action between the lignin of the wood and the cooking chemicals is still somewhat obscure, the general

* By kind permission of the Australian Paper Manufacturers Co. Ltd.

opinion at the present time is that the process is one of sulphonation and hydrolysis. The product of re-action—the pulp—is altogether different in colour from that obtained by the soda process. It may be almost white or faintly pink to pale buff, compared with the brown or dark grey of soda pulp. Still, though a sulphite pulp may appear light coloured and thus seem easily bleached, it may require much harder bleaching than a darker soda pulp. But where one pulp could be used unbleached in the manufacture of certain grades of paper, the colour of the other would entirely preclude it.

As the sulphite process is applied almost exclusively to the pulping of coniferous wood of low resin content, no information was available regarding the application of the process to the pulping of hardwoods that would serve as a guide to pulping the eucalypts. It was necessary, therefore, to start from the conditions employed on the softwoods and, by controlling the variable factors involved in cooking, to arrive at a set of conditions which would give the desired result regularly. It was soon seen that the regular cooking methods were not at all suited to the pulping of the eucalypts, just as the regular soda process gave but poor results. On the whole, the principal pulpwood eucalypts contain less lignin than coniferous woods, and furthermore, weight for weight, they present a greater surface to the attack of cooking chemicals, due to the shorter and very much more slender fibres, factors which it is believed account largely for the over-cooking and reduction of strength that results from treatment by regular methods.

A very careful systematic study of the application of the sulphite process to the pulping of eucalypts has been carried out in the past two years, principally with a view to developing a cooking schedule that would bring about the production of a pulp of special quality for use in the manufacture of newsprint. It had already been demonstrated, on a semi-commercial scale, that intrinsically the eucalypt fibre was one possessing sufficient strength to be used largely, if not alone, in the manufacture of fine printing paper. It became therefore a question of producing a pulp sufficiently white without bleaching, and one that required but slight beating to gain the requisite strength without becoming too "wet" to slow down the paper machine, or to give rise to a sheet that was too hard and rattly. These properties, it is believed, have been obtained by a combination of cooking conditions that differ rather markedly from those employed in cooking spruce and fir for news-grade sulphite pulp. The most striking differences lie in the duration of cooking which is nearly halved ($5\frac{1}{2}$ hours as compared with 10); the concentration of bi-sulphite which is raised about 50%; and the reduction of the maximum temperature to 140° C. instead of 150° C. The yield is phenomenally high—approximately 60% commercial pulp as compared with 45% to 50%—and more remarkable still is the fact that the pulp is easily bleached. Hence, if required, it could be used in the manufacture of other papers, as well as in the unbleached state in newsprint. It is a result that could scarcely have been anticipated when starting out with the standard cooking procedure for spruce, and it so altered the complexion of the cost of production, that the question of manufacturing newsprint, almost if not entirely, from this pulp was re-opened. At the present time a small complete pulp and paper mill is being

erected in Tasmania by a well-known company to test out the process on a scale that will decide whether the industry is one worth establishing.

(*b*) *From Exotic Conifers.*—In view of the fact that Australia is entirely lacking in indigenous timbers available in sufficient quantity for the production of long-fibred sulphite pulp, the planting of exotic conifers, such as spruce and fir, for this purpose has been considered on various occasions. The conclusions reached in this regard are, however, unfavourable. The consensus of opinion among foresters is that there is insufficient country of the requisite altitude, and possessing the proper soil and climatic conditions for growing these particular woods. We are, therefore, thrown back upon the need for producing these grades of pulp from coniferous wood that actually can be grown, and for the growing of which sufficiently large areas are available. *Pinus insignis* again presents possibilities. But so far the *Pinus* family has not been regarded at all favourably abroad as a pulp-wood. Where it has been tried, trouble has arisen from the resin left in the wood after sulphite cooking. This pitch, as it is called, clogs the wire of the paper machine, reduces production, and increases the cost. Will *P. insignis* or any other pine capable of being grown economically in Australia, do likewise? If so, can it be obviated, and at what cost? These are the questions that have to be answered before Australia can produce its own long-fibred sulphite pulp. The work in this direction has not yet proceeded far, but in view of its importance a decade or so hence, when ample timber will probably be available, the question is of great importance to the paper industry. With the ability to grow *P. insignis* on a short rotation, and to obtain from it both kraft and sulphite pulp, the paper industry would be almost self-contained.

### 5. Mechanical Pulp and Newsprint.

Associated with the production of a grade of sulphite pulp from the eucalyptus for use in the manufacture of newsprint, is the problem of grinding some of these woods into pulp for admixture therewith. The regular method at present employed in the making of newsprint is to grind spruce and fir into "mechanical" pulp, and to mix with three or four parts of this, one part of sulphite pulp from the same wood, prior to running on to the paper machine. The "freeness," or rate of drainage of the water from this mixture, has to be nicely adjusted in order to obtain the proper formation of the sheet, and to preserve the high running speed of the machine.

It has never been anticipated that mechanical pulp from the eucalypts could be used to the same extent as the product from the longer-fibred conifers, the whole ultimate fibres of which are two and a half times as long as the ultimate fibres of the eucalypts. In grinding, however, a great deal of disintegration occurs, so that the average length of coniferous groundwood fibre is comparatively small, and much of it acts both as a filler and a medium for controlling freeness and formation on the paper machine through its ability to prevent the water draining too rapidly. It was thought that by proper adjustment of the grinding conditions applied to certain immature eucalypts, a similar result could be obtained by mixing say, 20 per cent. or so of such product, with eucalypt sulphite pulp. Experiments along these lines were accordingly carried out, and it was found that, by a suitable treatment of the grinding stone, some

of the eucalypts notably *E. regnans* and *E. obliqua* could be ground so that when even 30 per cent. was mixed with 70 per cent. sulphite, a paper stronger than standard newsprint could be obtained on a laboratory scale. It is understood that part of the Tasmanian scheme previously referred to is to try out the use of groundwood in this way on a larger scale. Should it prove feasible at the speed at which modern newsprint machines are run, there is little doubt that a new industry will arise in the course of the next few years, and that this will itself quickly repay the money and effort expended on the Commonwealth Government's paper pulp investigations in the past eight years.

# Research on the Arid Flora of Australia.

*Memorandum prepared for the purposes of the Imperial Agricultural Research Conference (1927) by Professor T. G. B. Osborn, University of Adelaide.*

More than one-third of Australia has an arid climate, *i.e.,* it has under 10 inches annual rainfall. It necessarily follows that, except for irrigational agriculture, which can only be practised in a very small portion of the arid areas, the latter can only be used for pastoral purposes. The arid portions of Australia are essentially "station" country to be used in the production of wool and meat. The animals, both sheep and cattle, depend for their food on the natural vegetation of the district. This consists of various drought-resistant, low-growing, and sparsely scattered trees, together with low shrubs and a wealth of annual grass or herbage after rains. The low shrubs belong principally to the Chenopodiaceous genera *Atriplex* and *Kochia,* the salt and blue bushes. They are the most important permanent growth, cover over vast areas, though within the tropics they are replaced to a large extent by bunch grasses.

The importance of salt and blue bushes are two-fold. They provide valuable fodder during dry periods, when annual plants are absent, and they protect the soil from erosion. The effect of continuous or heavy grazing is to destroy the salt and blue bushes, by trampling as well as by browsing. These effects are most marked in zones varying up to as much as 2 miles from permanent waters. Stock, and especially rabbits, prevent the regeneration of trees and shrubs by eating down seedlings.

As a result of the disturbance of the biologic factor, the natural vegetation in arid parts of Australia is being destroyed, and there is nothing permanent to replace it.

Investigations are being made at Koonamore (north-east of South Australia, 8-inch rainfall), upon an area of eaten out saltbush, 1,000 acres in extent, which has been given to the University of Adelaide as a vegetation reserve for research work, conducted by the Department of Botany. The objects of the investigation are:—

(i) To study the regeneration of natural vegetation, particularly of saltbush and trees in an over-grazed area, when all grazing influences, including those of rabbits, are removed.

(ii) To study the effect of grazing of known intensity on the process of regeneration.

(iii) To study the ecology of the area, and particularly the autecology of the species that are most valuable economically.

Work has been in progress for over a year within the area on lines (i) and (iii); number (ii) cannot be proceeded with until regeneration has proceeded further.

The conditions on the Koonamore reserve are typical of much of the salt bush area in Australia. Extension of the work into other arid districts is under consideration by the Council for Scientific and Industrial Research.

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# Spotted Wilt of Tomatoes.

*Preliminary note concerning the transmission of the "Spotted Wilt" of Tomatoes by an insect vector* (Thrips tabaci *Lind*), *by H. A. Pittman, B.Sc.Agr., Assistant Plant Pathologist, Waite Agricultural Research Institute, Adelaide.*

Mr. Pittman is an officer of the Council, and by kind permission of the controlling authorities of the Waite Institute has been stationed at the Institute, in accordance with the scheme mentioned in the previous issue of *Journal* (pages 15 and 16).—Ed.

In connexion with the investigation of the "spotted wilt" disease of tomatoes which is being carried out at the Waite Institute in co-operation with the Council for Scientific and Industrial Research, it has been possible to determine, with a reasonable degree of certainty, that the disease is a "virus" disease, transmitted by means of an insect vector (*Thrips tabaci* Lindeman).

Progress has been accelerated through the completion, in April, 1927 (by the Council for Scientific and Industrial Research), of an insect-proof glasshouse, subdivided into one large compartment and a number of smaller ones. The work described has been almost entirely conducted in this glasshouse.

With reference to the aetiology of the disease, all investigations so far conducted in Australia would indicate that the causal agent is almost certainly of such a nature as not to be microscopically demonstrable. Brittlebank (2) writing in 1919, stated that all efforts to reveal or to isolate a causal organism failed, and no method of control could therefore be devised. Hamblin (3) found that the diseased plants appeared to be quite free from any causal fungal or bacterial parasite. These workers also failed to produce the disease in healthy plants by means of inoculations with the sap of diseased plants, or by the insertion of crushed diseased tissue.

The absence of any demonstrable parasite in diseased tissues was confirmed at the commencement of the investigations on the disease carried out at the Waite Institute. The evidence which has accumulated as to the probable "virus" nature of the disease may be summarized as follows:—

(i) All investigations so far conducted by pathologists in Australia have failed to reveal the presence of any demonstrable causal organism in diseased plants.

(ii) The disease does not appear to be causally related to any soil or environmental conditions, in so far as it occurs over many widely differing soil types, and under climatic conditions varying from those of Brisbane on the one hand, to those of Perth on the other. Observations in general would indicate that a feature of the disease is its marked indifference to the manurial or physical treatment of the soil.

(iii) More direct evidence is to be found in the fact that if badly affected plants can be induced to grow away, after the first severe check given by the disease, they will almost invariably develop a pronounced mosaic-like condition of the foliage, thus indicating the probably affinity of the causal agent with the "virus" group.

(iv) It appears, moreover, that plants can be maintained free from the "spotted wilt" disease so long as they be grown under insect-free conditions.

Some hundreds of plants have grown in the insect-proof glasshouse at the Waite Institute, without a single plant becoming spontaneously diseased. In commercial glasshouses in the immediate neighbourhood, however, the disease has been relatively frequent during the same period, the only major difference in the two cases being that the structure of the commercial glasshouses is not such as to maintain the plants insect-free. Similar evidence was obtained from observations made at Burnley, Victoria—

> "Twenty-two plants protected from insect attack, produced an average of one case each of sound marketable fruit, as against one case (only) from 132 plants not protected, of the same varieties, planted in the same rows at the same time, with seedlings raised under the same conditions."*

In the light of the above evidence, it would seem likely that the disease is due to the presence of an ultra-microscopic agent in diseased plants, which is transferred to healthy plants by an insect vector. Moreover, in so far as the attempts of Brittlebank (2), Hamblin (3), and the writer, to transmit the disease by the inoculation of healthy plants with the expressed juice of diseased plants, have all failed, it would appear likely, from analogy with several other virus diseases, that but a single insect species is concerned in the transmission of "spotted wilt," as, for example, in the cases of "Curly-top" of sugar beets, (1, 5, 6, 7), aster "Yellows" (4) and the "Streak" disease of maize (8).

In an attempt to find an insect vector, the following insects prevalent at the Waite Institute during the season 1926-27 have been experimented with, viz.:—

(*a*) Jassids (*Empoasca sp.*).

(*b*) Aphids.

(*c*) Red Spiders (*Tetranychus telarius* Linn.).

(*d*) A very small four-legged, as yet undescribed mite, found in large numbers on tomato plants at the Institute at the close of the past season. These mites are invisible to the naked eye, and are very similar in size and form to the pear-leaf blister mite, *Eriophyes pyri*, but they live free on the surface of the plants and do not form galls or blisters.

* Cited by W. M. Carne "Spotted Wilt of Tomatoes," Leaflet 116, Department of Agriculture, Western Australia.

The insects were first fed for considerable periods on diseased plants, and were then transferred to healthy seedlings, ranging in number from 20 to 70 plants, in each experiment. None of the above insects was found able to transmit the disease. An experiment was also conducted in a commercial glasshouse with the "White Fly," *Trialeurodes vaporariorum* West, but the disease was not transmitted. Full details of these experiments will be published later.

When all the above insects failed to transmit the disease, the writer determined to experiment with the onion or rose thrips, *Thrips tabaci* Lindeman, considerable numbers of which had been noticed on the plants of the experimental plots during the previous season. It was found, however, that owing to the winter weather, most of the insects normally present on the tomato plants had disappeared, and only fifteen larval thrips were found feeding on some diseased plants in a protected situation.

*Thrips Transmission Experiment No.* 1.

On the 25th June, 1927, these fifteen larval thrips, taken from diseased plants, were transferred, to the number of three in each case, to each of five healthy young Golden Queen seedlings, growing in 8-inch pots under large lamp globes, covered at the top with fine muslin. Five control plants, grown from the same lot of seed, under identical conditions, in the same seed box, were similarly arranged and placed alternately to the test plants. On the sixteenth day of the experiment (11th July), three of the test plants showed the first symptoms of "spotted wilt" and ceased to grow. On the twenty-third day (18th July), the fourth test plant developed the disease, and on the thirty-fifth day (30th July), the remaining plant of the five developed it. As each of the test plants developed the symptoms, it ceased to grow, but the alternately arranged control plants remained perfectly healthy and continued growing at the normal rate (Fig. 1, Plate 1).

*Thrips Transmission Experiment No.* 2.

It was immediately desired to arrange a confirmatory experiment, but no further thrips could be found on the plants at the Waite Institute. However, through the courtesy of Mr. Mitchell, of West Welland, in whose commercial glasshouses a certain amount of "spotted wilt" was present, a number of larval thrips were obtained from diseased plants. On the 19th July five larval thrips, taken from diseased plants, were placed on each of five healthy Burwood Prize and five healthy Golden Queen seedlings, under muslin covered lamp globes in 8-inch pots. Five similar plants of each variety, similarly treated, except for the absence of thrips, were kept as controls and were arranged alternately to the test plants.

On the sixteenth day of the experiment (4th August), four of the Burwood Prize test seedlings first showed the symptoms of "spotted wilt" and ceased to grow. No further disease appeared until the thirty-first day when one of the five Golden seedlings developed the characteristic bronze symptoms on the upper surfaces of the youngest leaves (23rd August). On the forty-second day (30th August) a second Golden Queen seedling developed the disease, and on the forty-ninth day (5th September) still another.

As the larval thrips only feed for a few days on the tomato seedlings and then drop to the ground to pupate, the lamp globes were removed from all the test and control plants on the sixteenth day of the experiment. All plants were then allowed to remain uncovered,

side by side in the same compartment. All the control plants remained perfectly healthy and continued to grow rapidly in marked contrast to the diseased plants adjacent to them (Fig. 2, Plate 1).

*Thrips Transmission Experiment No.* 3.

Further attempts to obtain thrips in large numbers from the above mentioned commercial glasshouses were unsuccessful, as the disease had to a large extent been checked. Considerable numbers were obtained, however, from the under surfaces of hollyhock (*Althaea rosca* Cav.) and *Cineraria* leaves, and after feeding these on "spotted wilt" tomato plants, for periods varying from two to twelve days, they were transferred in varying numbers, and on varying dates—commencing 19th August—to healthy tomato seedlings of the variety Sensation. For this experiment the control plants are being kept in the adjacent compartment of the insect-proof glasshouse, no globes being used on the test plants or on the controls. At the time of writing (10th September), six of the test plants have developed "spotted wilt," the controls being perfectly healthy. The incubation period of the disease in these plants has been approximately sixteen to twenty days.

*Identification of Thrips.*

The identification of the thrips used as the onion or rose thrips—*Thrips tabaci* Lindeman, has been made by Mr. A. M. Lea, of the Adelaide Museum. So far only the larvae have been used, on account of the scarcity of adults, and the difficulty of handling these, but it is likely that under natural conditions it is the winged adults which transmit the disease from plant to plant. The larvae only feed for several days on the plants before falling to the ground to pupate, and frequently the feeding marks are so slight as to be very easily overlooked.

*Conclusion.*

In conclusion, it would seem to be established that the "spotted wilt" of tomatoes is transmitted by means of the onion thrips—*Thrips tabaci* Lindeman. The disappearance of the insects from the plants in most cases long before the symptoms of the disease become evident, may account for the fact that their relation to the "spotted wilt" disease has not previously been suspected.

## REFERENCES.

(1) *Ball, E. D.*—"The Leafhoppers of Sugar Beet and their Relation to the Curly Leaf Condition." U.S.D.A. Bur. Ent. Bul. 66, 33-52, 4 plates, 1909.

(2) *Brittlebank, C. C.*—"Tomato Diseases—A New Disease," *Jour. Agric., Vic.*, Vol. 17, 231-35, 1919.

(3) *Hamblin, C. O.*—"Spotted Wilt of Tomatoes," *Agric. Gaz. N.S.W.*, Vol. 32, p. 50, 1921.

(4) *Kunkel, L. O.*—"Studies on Aster Yellows," *Amer. Jour. Bot.*, Vol. 13, 646-705, 5 plates, 4 figs., 1926.

(5) *Severin, H. H. P.*—"Curly Leaf Transmission Experiments," *Phytopath.* Vol. 14, 80-93, 1 fig., 1924.

(6) *Shaw, H. B.*—"The Curly-top of Beets," U.S.D.A. Div. Bot., Bul. 181, 1-46, 9 plates, 9 figs., 1910.

(7) *Smith, R. E.*, and *Boncquet, P. A.*—"New Light on Curly Top of Sugar Beets," *Phytopath.* 5, 103-107, 3 figs., 1915.

(8) *Storey, H. H.*—"The Transmission of Streak Disease of Maize by the Leaf-hopper, *Balclutha mbila* Naude." *Ann. App. Biol.* Vol. XII., No. 4, 422-39, 3 plates, 1925.

# St. John's Wort—Possibility of Biological Control.

*Report by Dr. R. J. Tillyard, F.R.S.*

In 1926, Dr. R. J. Tillyard, F.R.S., Assistant Director of the Cawthron Institute, New Zealand, visited Europe and America for the purpose of making inquiries regarding the development of research work on the biological control of weed pests and insect pests in New Zealand. Dr. Tillyard kindly undertook to make inquiries also regarding insect enemies of St. John's Wort (*Hypericum perforatum*), which is a serious pest in the north-eastern parts of Victoria and in the adjacent districts of New South Wales.

On his return to New Zealand, Dr. Tillyard furnished a report on his inquiries on insect enemies of St. John's Wort. The opportunity has been taken of his present visit to Australia to arrange for an inspection by him of the principal districts infested by the pest in Victoria, with a view to taking steps to investigate the practicability of biological control. The report which he furnished as a result of his inquiries in 1926 is printed below in slightly abridged form.—Ed.

Having spent the last few months travelling in Europe with the principal object of ascertaining the possibilities of control of certain weeds which have become serious pests in Australia and New Zealand, by means of their natural insect enemies, I am now able to make the following report on a problem of special interest to Australia, viz., the control of St. John's Wort *Hypericum perforatum*. The assumption underlying this report is that the attempt to control this weed by its insect enemies may be made in Australia, provided it can be shown:—

(*a*) That the insects recommended for introduction will not feed at any stage of their life-history upon plants other than those of the genus *Hypericum;* and

(*b*) That the same insects, if introduced into Australia, have a reasonable chance of controlling the weed.

Generally throughout Europe during the past summer (1926), St. John's Wort, like most other plants, has been remarkably free from insect enemies, the principal cause being the heavy mortality amongst insects during the late frosts of April and May. In many places, however, especially late in the season, considerable damage by insects became apparent. A study of the various insects causing different types of damage to the plant showed at once that the genus *Hypericum* possesses a fairly large insect fauna attached to it, and a large proportion of these insects appear to be entirely confined to this genus.

The following are the most important species of insects noted as attacking *Hypericum*:—

## A. Insects Attacking the Leaves.

1. *Chrysomela hyperici* and *Chr. varians*.—These are the most noticeable of the insect enemies of *Hypericum*. Both occur widely in Great Britain, *Chr. hyperici* apparently being the commoner of the two. These beetles are double-brooded, and pass the winter in the adult state. The first-brood larvae are found in June-July, the second brood larvae in August-September. The second brood is known to be oviparous, but the first brood has been stated to be viviparous. This type of life-history is of great importance in considering the probable value of the insect under Australian climatic conditions. In the warmer climate of Victoria, it may reasonably be expected that a race would soon develop with a much shorter hibernating period, a larger number of broods per annum, and

complete viviparity, thus shortening the time between broods. Thus the rate of increase of the insect might become enormous, and the chief problem to be faced would be the possibility of such a ravenous leaf feeder attacking other species of plants.

Assuming, as seems probable, that experiments show that these insects do not attack any plant other than *Hypericum,* I am most strongly of opinion that both these species, and, if possible, other allied species found in Europe, but not in England, should be imported into Australia and tested out under strict control conditions in closed insectaries, on the same lines as have been laid down in the work on prickly pear control. A liberation of any species of *Chrysomela* in the infected area of Victoria can only be made after the most exhaustive and thorough tests have been carried out as to the capacity of these insects to attack any other plants of economic value under Australian conditions. If these tests show an entirely negative result, then I believe that these beetles will prove of great value in controlling the pest.

2. *Anaitis plagiata* and *A. effumata.*—The first of these is a fairly large (*Geometer*) moth called the "Treble-bar," and the second is a closely allied species often confused with it, and very difficult to distinguish. The larvae are looper caterpillars, which feed voraciously on the leaves, and also sometimes in the flower-heads of *Hypericum.*

Although all the text-books give *Hypericum* as the only food-plant of these species, yet I have collected a considerable amount of evidence to show that the moths appear very commonly in localities where *Hypericum* is rare and absent. It seems highly probable that the larvae eat other plants. Consequently, I must stress the importance of original research work being done in England on these species, in order to discover on what plants besides *Hypericum* the larvae feed. Supplies of *A. plagiata* can be rapidly purchased from dealers, but I am strongly of opinion that no attempt should be made to introduce this moth or the allied species until a complete series of food tests has been carried out.

3. *Tineoid Moths Attacking Leaves and Shoots.*—A number of these are known including, in Great Britain, *Depressaria hypericella, Gracilaria auroguttata, Epinotia hypericana,* and *Aristotelia atrella.* The first named spins the shoots together, and does considerable damage when abundant. It may be considered of distinct value in preventing flowering of the plant. Much needs to be discovered about the life history and food plants of these small moths before they could be considered as possible introductions into Australia.

### B. Gall-formers.

*Hypericum* is attacked by a number of gall-forming species, the most important of which are the Diptera *Perrisia hyperici* and *P. serotina.* Both destroy the flowering shoots, the former making a rosette of a number of infolding leaves, while the latter attacks only the two terminal ones. *Rerrisia braueri* is exceedingly promising as its larva stops the shoot while still underground. These insects are commonest in fairly warm localities in Europe, and should do remarkably well in Victoria. As their galls are quite characteristic and confined to *Hypericum,* immediate importations may be recommended, provided that they are received into closed insectaries, and subjected to severe food tests before

any decision is taken about liberating them. If the attempt to establish them proved successful, I am of opinion that they would almost completely prevent the plant from seeding.

### C. Seed-Capsule Feeders.

I have seen a larva feeding in the seed capsules which appears to me to belong to a species of *Apion*, but I have not been able to rear it. If there is a species of this genus of weevil confined to *Hypericum*, it will prove of the utmost value in controlling the weed, as the habits of this larva are such as entirely to prevent the setting of the seed. Very careful observations on the seed capsules of *Hypericum* in different parts of Europe are required in order to discover how far they are attacked by such insects as these.

### Recommendations.

In view of the foregoing facts, I desire to make the following recommendations:—

(i) That the policy of attempting to control *Hypericum* in Australia by means of its insect enemies should be officially recognized as a sound policy scientifically, offering very promising chances of final success.

(ii) That arrangements be made for as complete a study as possible of the life histories of *Hypericum*—feeding insects, to be carried out in England.

(iii) That food tests of these insects be made on all important economic plants common in Europe and Australia (introduced).

(iv) That only such species as give negative results in the tests (iii) on all plants, except species of *Hypericum*, should be permitted entry into Australia.

(v) That species brought into Australia should be reared in closed insectaries under the strict control of experts, and that they be subjected to further food tests as regards Australian plants of economic importance.

(vi) That only such species as give (*a*) a negative result with test (v) and (*b*) appear from their habits in the insectary to promise useful results in controlling *Hypericum*, should be finally experimented with in the infected areas in the open.

# The Australian Meat Industry.

*Report prepared at the request of the Council for Scientific and Industrial Research by the New South Wales State Committee of the Council (February, 1927).*

Prior to the Council considering the question of cold storage research, it arranged to obtain reports on various aspects of that problem from some of its State Committees, and from the Meat Freezing Committee of the Australian National Research Council. The report of the latter was published in the last issue of this *Journal*. The report of the New South Wales State Committee is given below. It was the work of a special sub-committee consisting of Professor J. D. Stewart, Chairman; Mr. J. B. Cramsie, Chairman of the Metropolitan Meat Industry Board; Mr. John M. Davidson, Veterinary Officer, Department of Trade and Customs; Sir Graham Waddell, President Graziers' Association of New South Wales; and Mr. F. J. Walker, Meat Export Agent.—Ed.

1. General.
2. Transportation of Live Stock.
3. Treatment at Works.
4. Transportation Problems.
5. De-frosting.
6. Recommendations.

## 1. General.

As it became evident during the preliminary discussion that the problems associated with the freezing and chilling of meat were intimately connected wtih those of other branches of the meat industry, and as many are common to the supply of beef for both the export trade and the local markets, it was considered that the Committee would render better service by reporting on the problems of the meat industry as a whole.

It does not appear to be generally recognized that about 86 per cent.of the large quantity of beef treated in Australia is required for the local markets; the annual consumption of beef per head of population here during the three years ending 1923-24 being 143.7 lb., which is large compared with 68 lb. in the United States of America, and 64.03 lb. in the United Kingdom, for the same period. Obviously the requirements of the local markets predominate. Still, the fact that only about 14 per cent. of the beef treated is exported must not be regarded as indicative of the relative unimportance of the export trade, as the future development of our beef industry is largely dependent on the profitable transportation to oversea markets of the surplus that remains after local requirements have been supplied. That an extensive market does exist for this surplus in Great Britain alone is clearly indicated by the recently published returns of the British Board of Trade, which gave the value of Australian frozen meat imported during year 1925 as £5,347,813, out of a total value of beef from all countries of £52,523,590, or only about 10 per cent. Moreover, it would appear that, in the future still greater opportunities will obtain in Great Britain for the marketing of Australian beef, owing to the gradually diminishing amount of beef available for exportation in several of our chief competing countries, where the demands for local requirements are over-taking the amount of beef produced.

Beef statistics show that, in the United States of America, which is the greatest beef producing country in the world, since the year 1920 up till the end of last year, there had been a decline in the numbers of beef cattle of 10,700,000 head, or 24 per cent. of the total number; and further inquiries in that country prove that, in order to feed their 112,000,000

people, they have been compelled in many instances to place their yearling stock in the corn fattening paddocks to meet the increased demands of their rapidly increasing population. This increase of population is estimated at 2,000,000 per annum, and, at the present time, fully 70 per cent. of the slaughtered cattle in the United States of America are artificially fed and fattened to meet the requirements of the population.

With regard to the Argentine, statistics show that cattle numbers are not increasing, but, if anything, are slowly declining, which is supported by the fact that her export figures in 1925 and 1926 are in each case lower than those of the previous year. Uruguay cattle numbers show a very slight increase, but her sheep numbers are steadily increasing, and any increased export of meat from that country will be in the direction of mutton and lamb.

Patagonia is steadily increasing her production of mutton, and is now the second largest exporter of mutton and lamb to the United Kingdom. New Zealand is not increasing either her cattle or sheep numbers, and remains approximately stationary in her exports of frozen beef, mutton and lamb.

Australia is steadily declining in her exports of beef as shown by the fact that this year's export will not be 50 per cent. of the previous year, and there is every likelihood of the next two years being, if anything, less than the present year, as a result of the recent heavy losses in Queensland from drought. It is therefore obvious that there exists an extensive field for the expansion of our meat export trade, and as this expansion must encourage the more profitable utilization of vast regions in the northern portion of our continent, sympathetic action to stimulate the growth of the beef industry must necessarily form part of any comprehensive scheme elaborated for developing the productivity of Australia. Markets abroad, however, will never be captured by just dumping into them large quantities of beef without proper regard to its quality, and it is a significant fact that, in the returns referred to above, the value per ton of beef from Australia is given as £56, while that of the total beef imported as £59. This recognized inferiority of Australian meat is due to several factors, and while the methods employed in slaughtering, dressing, and transportation have an important influence, the chief and primary cause of much of the low-grade meat produce is the want of enterprise on the part of many cattle breeders, who have failed to improve their herds by the introduction of new blood of modern strains to assure early maturity. The day of the big-framed, long-legged, aged bullock as a beef producer has passed, for housewives now demand small juicy joints in the retail trade. In catering for this demand the Argentine and other exporting countries have spent enormous sums in herd improvement, especially by the importation of large numbers of quick maturing bulls of the highest quality. A similar policy must be adopted for Australia, and while this development is purely a matter for private enterprise, it is understood that some assistance is to be afforded in the granting of concessions in freight, as a result of the operations of the Imperial Economic Committee in regard to shipments of stud stock.

*Improved Beef Breeds.*

Hitherto British breeds of cattle have been exclusively used in building up our herds of beef producers, and the progress made is a striking

tribute to the adaptability of many of these breeds, for each has been evolved by generations of selective breeding to suit the environments and meet the requirements of its particular place or origin. They have generally done well in the southern half of the Continent, but it is open to question whether they are the best breeds conceivable for much of our tropical, and even sub-tropical, territory, where cattle breeding is so extensively carried out, owing to their susceptibility to certain diseases, and to attack by insects that prevail in these regions. Knowing that Asiatic cattle, from constant exposure for many generations to tropical diseases and insects, have acquired a high degree of tolerance to them, it would appear that the most suitable type of cattle for our northern areas has yet to be evolved by inter-breeding British and Asiatic strains. In America, zebu cattle have been used on Hereford and Shorthorn breeds, and the progeny have shown considerable resistance to the cattle tick, but whether the zebu is the most suitable Asiatic breed to introduce, or the breeds mentioned are the best to use with zebu cattle, experimental investigation alone can determine. As the solution of this problem will undoubtedly have an important influence in encouraging the more profitable occupation of the vast territory in the north, the establishment of a cattle breeding experiment station in these regions becomes a matter worthy of serious consideration by the Federal Government.

Of recent years, that branch of veterinary science known as animal genetics, has been greatly advanced, and is now capable of rendering much useful service in increasing the productivity of the various branches of our live-stock industry, by improving existing breeds and evolving new types. A direction in which it can be immediately applied with advantage is in the breeding of hornless cattle. "Polled Durham" and "Polled Hereford" cattle have already been evolved in America, and although many breeders of pure-breds may regard a hornless beast as a mutilated specimen of his particular breed, it must be admitted that for the majority of our cattle, and more particularly for those in settled areas, the horns are not only unnecessary as weapons of offence and defence, but are often a distinct handicap to the individual and a source of trouble to his fellows: their possession leading to loss in beef. Consequently it would appear that in the future there will be a demand on economic grounds for guidance in the conversion of our horned breeds of cattle into hornless ones. Provision should be made for this demand.

It is therefore evident that the encouragement of animal genetics, and the application of more scientific methods in the breeding of cattle for beef production, must play an important part in any complete scheme for the improvement of the beef industry in Australia.

*Continuity of Supply.*

It must be recognized that the acquisition of bulls of improved strains is but the first step towards the production of better beef. To obtain even satisfactory results from these early maturing strains, the progeny must receive a constant and sufficient supply of food. Also, water should be provided at stages not more than 5 miles apart, and the necessary fencing should also be erected to keep the sexes apart, especially the young growing females from the bulls, until such time as they are fit to be mated. As is well known in Australia, cattle are grazed on natural pastures for beef production; in good seasons when the grasses and herbage are abundant, the supply of fat cattle is bounteous, but during periods of drought when the pastures become

bare, the condition of our cattle wastes, and operations at meat works have to be curtailed. Consequently, improved feeding becomes the natural corollary of improved breeding, and its attendant difficulties are at least equally great. They include pasture improvement, fodder conservation, and nutrition problems, all of which are subjects for scientific investigation. Pastures in closer settled areas can undoubtedly be improved by treatment with chemical fertilizers and the introduction of better grasses, but direction is often lacking as to exactly what fertilizer should be used in different areas, and which of the grasses are best to introduce. With increased growth of pastures the conservation of fodder in the form of hay or silage becomes easier, but in order to obtain the best results there is a vast amount of work to be done in ascertaining the nutritive value of native and introduced grasses, herbage, and scrubs. As the solution of these problems must of necessity absorb many years of effort, and as the necessity for improving the quality of our beef is urgent, some quicker method of bringing about necessary reform is desirable, and the opinion is expressed that it is possible to attain an improved and constant supply of beef by encouraging farmers to undertake the "topping up" of cattle for the market. Of recent years, owing to the demand and relative high price of wheat, the development of farming in Australia has been mainly concentrated on the cultivation of this cereal, but reliance on the one market is always a risky procedure. To sustain continuity of progress in the development of agriculture, it is necessary to increase the number of sources from which revenue is obtained. Many successful farmers combine fat lamb raising with wheat cultivation, but the majority have hitherto held off cattle fattening by hand feeding, owing to the prevailing view that it will not pay, notwithstanding the advanced prices prime cattle fetch in the local markets. While the different Departments of Agriculture have given considerable attention to improving the fat lamb trade, practically nothing has been done with regard to the experimental fattening of cattle by hand feeding, and it is considered that this is a direction in which the Council for Scientific and Industrial Research can render very valuable services by instituting a series of trials at some of the Agricultural Experimental Farms. If the procedure can be shown to be profitable to the farmer, not only will a marked improvement in the quality of our meat be quickly brought about, but the supply of cattle in prime condition will be far more continuous than under existing conditions.

The rise and fall in the prices cattle bring in local markets and the costs of operations at the meat works are largely dependent upon continuity of supply. So far as the markets of Great Britain are concerned, experience has shown us that there must be a continuity of supply if we are to secure the desired demand for our meat products. The whole question of supply naturally rests on the question of production. In a country such as Australia, where the climatic conditions are erratic, and where the rainfall is uncertain, it is imperative that some provision be made for the production of a continuous supply.

In the successful meat producing countries experiencing the greatest demand and highest prices for their meat, either regular climatic conditions, or provision for artificial feeding to carry the stock over both the growing and fattening periods by the use of cultivated fodders, has secured this success. In the United States of America,

corn feeding is general, and fully 70 per cent. to 75 per cent. of their cattle are fattened on cultivated fodders. In Canada, provision is made not only for fattening cattle for the market, but also for feeding young stock throughout the winter periods. In the Argentine, huge areas are under alfalfa, and during lean periods the cattle are fed on this fodder previously placed in stacks. As the weather conditions improve, the cattle are turned on to the growing alfalfa, with the result that a continuous supply of prime beef for export to the markets of Great Britain is assured. In Uruguay where the growing of alfalfa has proved much less successful than in the Argentine, the supply of cattle has proved much less regular and continuous than in the latter country.

As far as mutton and lamb are concerned it is only necessary to compare New Zealand—which practically carries on her production with the artificial growth of grasses and crops—with Australia which carries on her industry with natural grasses, and it will be seen that while the former is continuous in her operations and regular in her supplies, the latter is most erratic.

Dealing with Australia, before we can ever expect to secure a maximum demand, which means maximum prices, it will be necessary for at least portion of our stock to be artificially fattened to enable the continuity of supply to be available for those clients who are prepared to handle our meat products, and any scheme which has for its object the improvement and extension of our meat export industry must have, as its basis, improved production and continuity of supply.

We are told that Australia is placed at a decided disadvantage on account of her recurring dry periods, but one has only to compare those dry periods—which occur possibly once in three or four years—with the recurring snow period of Canada, during which the stock in that country have to be artificially fed for five or six months each year, to recognize that we are not at any great disadvantage compared with Canada. The United States of America has its dry periods also, but as most of the stock are artificially fed for the whole period little effect is felt, and such countries as the Argentine and Uruguay, while they may have a much more even rainfall, suffer from regular visitations of grasshoppers and locusts, against which they provide by conservation of fodder. This enables them to keep their stock in good condition until such time as these pests have passed, and a following rain has made their pastures good again.

If we are to compete with our opponents successfully, we must do as they do, and make similar provision to meet our adverse conditions, so that we shall not suffer heavy losses of stock in dry periods but shall be in a position to produce, fatten, and market, approximately a similar number of stock each year to provide continuity of supply.

## 2. Transportation of Live Stock.

The average person who is not connected with the meat industry fails to recognize the necessity of speedy and smooth transportation of stock from the pastures to the treatment works. Until some three years ago, the stock trains in the State of New South Wales were operated at slow speeds, and very lengthy periods of transport resulted over long distances. As the result of repeated applications to the Railway Commissioners the service was accelerated, and approximately 30 per cent. of the running time occupied was cut off, the

trains being run with a lessened number of wagons. Prior to this, as a result of consultation between representatives of the producers and of the Commissioners of Railways, improvements were made in the design of the cattle wagons and sheep trucks. Since these alterations, stock are delivered in very much better condition and with considerably lighter losses and less bruising.

A feature which is often lost sight of in connexion with the handling of stock is the care that must be exercised both during travelling and trucking. It frequently happens that sufficient time has not been allowed to travel the cattle from the paddocks where they have been fattened, to the railway yards, and as a result hurried droving becomes necessary and loss of condition takes place. In many cases the cattle are not properly watered during droving and preceding trucking, with the result they do not travel well. Often on arrival at the railway yards they are worked with unnecessary noise and hustle, leading to much bruising and knocking about. Trucking should be carried out as quietly as possible; pointed sticks should not be used and dogs should be kept away. Once cattle get excited it takes many hours for them to settle down, and restlessness wastes condition. Cheap droving and trucking are not in the best interests of the owner of fat stock.

In railway transportation, one must take into consideration the surface of the country over which such transportation takes place. Comparing the railways of this State with those of the Argentine, it must be remembered that our trains in many instances have to pass over altitudes of from 1,000 to 3,000 feet, and have to travel round curves of small radii to enable such altitudes to be climbed in reasonable grades, whereas in the Argentine fully 80 per cent. of the stock delivered to the principal meat works at the different centres, journey over practically flat country with hardly any noticeable curves. Again our fattening areas are situated long distances from the points of treatment, which is not the case in the Argentine where the country suitable for stock production commences almost at the points of treatment, and the majority of stock are transported much shorter distances than in the case of the larger States of Australia. Moreover, in the Argentine, on account of the general richness of grazing areas, the country is more heavily stocked and is much better served with railways than is the case in Australia, and consequently much shorter distances of droving take place. They have therefore the distinct advantages of short road travel, speedier stock trains over level country, and shorter rail transport.

It has always been recognized in connexion with common railway practice, that altitude governs both speed of trains and cost of transportation, and if one compares the conditions existing in the Argentine with those in Australia, our transport conditions are not much behind theirs, with the exception that in most cases they use much larger wagons which run much more smoothly than our own. If it were possible to use bogie wagons only, and to accelerate the speed of our trains a further 10 per cent. to 15 per cent., our service should compare favorably with regard to conditions of transport, but this may not be the case with cost of transportation.

In order to handle successfully the early maturing chiller steer when properly fattened, smooth and rapid transport is necessary, as

the flesh of such animals is tender and easily bruised. The Argentine cattle are well handled and properly quietened, and as a result less bruising takes place. Being educated to feed on hay and drink from troughs, instead of depreciating in value while being rested for 48 to 72 hours prior to slaughter, they improve, and enter the slaughter halls showing no sign of travel or depreciation as a result of removal from their fattening pastures. Good handling in the early period of an animal's life makes for rapid growth and quick fattening.

## 3. Treatment at Works.

Under this heading consideration must be given to both the edible and the inedible sections, and in briefly describing each, the main features referred to will be those which it is considered can, with very little effort on the part of the operators, be considerably improved to the general benefit of the industry.

*A. Edible Material.*

In order to obtain a minimum amount of bruising and excitement of the animals, both of which result in serious damage to the meat, careful unloading and handling of stock are essential. Prior to slaughter the resting of stock is necessary, and for best results with beef, the cattle should be treated with cold water showers.

(i) *Slaughtering.*

When "sticking," in order to keep the blood free from paunch contents, a simple device in the form of an aluminium spring clip applied to the oesophagus has been successfully used by some Queensland firms, and could easily be adopted elsewhere. This not only protects the tongue and checks from contamination (a very necessary precaution), but it increases the value of the blood manure.

Sufficient time should be given for the animal to bleed before further dressing takes place. This matter is very much neglected by some beef operators in the local trade and results in "fiery" carcasses, the meat of which is prone to deterioration from putrefactive processes owing to the veins being filled with blood clots.

The dressing of local trade meats in general is carelessly carried out, as is seen by the unsightly carcasses and unnecessary damage to hides and skins. A simple device used in Queensland is a patent cutter for dividing the pubis or the aitch bone of cattle. This leaves intact the film or fascia over the inside of the thigh muscles, which otherwise present a raw surface that consequently darkens on exposure. Also neat dressing about the hock and the use of clean hooks, are absolutely essential for the good appearance of hindquarter beef. For export beef, it is compulsory to use a saw for dividing the spinal column, and it is considered this could be beneficially used for local trade beef. Further, the best results are obtained by carefully wiping hindquarters, &c., of beef, with a warm damp cloth, and by avoiding the excessive use of water on the carcass.

(ii) *Chilling and Freezing.*

As soon as possible after slaughter, all meats for the export trade are placed in cool rooms, thus preserving the bloom on the meats, and by reducing the temperature, inhibiting the growth of putrefactive bacteria, &c. In this respect, it is considered that it should also be compulsory for all meat for local trade to be thoroughly chilled before it leaves the meat works for disposal to the retail butchers.

Matters of vital importance to the Meat Industry are the determination of (1) the most suitable conditions for chilling operations and the most suitable temperature at which chilled meat should be held, and (2) the most suitable temperatures and methods for the freezing and holding in stores, of various classes of meat (beef, veal, mutton, pork, and sundries such as hearts, tongues, cheeks, livers, &c.) Research is further desired to determine the accurate percentage of loss of weight in various classes of meat when chilled or frozen, and also the progressive loss of weight which occurs from lengthy storage at different temperatures. It is suggested that in dealing with these matters the commerical aspect should be taken into consideration. From time to time numerous patents are advocated for chilling and freezing, but while many may be scientifically sound, some are commercially impracticable, and one must therefore stress the point that when any experimental work is to be carried out, the commercial as well as the scientific side, should always prominently be borne in mind. It is considered that any scheme put forward for the carrying of chilled meat should be tried out under supervision at one of the freezing works at some centre such as Brisbane, Sydney, Melbourne, &c., where proper observations can be made, and temperatures and conditions verified. In the event of this trial proving satisfactory the question of an export consignment by one of the overseas vessels should then be considered.

It is pointed out, however, that at present in Australia, the general quality of the cattle is such that there are not sufficient quantities of suitable beef treated at any one works to provide a payable consignment of export chilled beef, but where small weekly shipments can be made, it is thought that some consideration might be given to an interstate trade of such beef from Queensland to Sydney or Melbourne, during certain periods of the year. A further matter which might be considered is the transport of chilled meat by rail from a large killing centre to more outlying country districts.

(iii) *Preserving.*

In connexion with preserving meat, owing to the different opinions regarding the use of cold or hot pickle, and the fact that for some years both have been used without a decision being arrived at as to which is the better, this Committee would respectfully suggest that an investigation be carried out in this direction to prove which method gives the better result.

(iv) *General.*

In all meat operations, it should be prominently borne in mind that the principles of hygiene and sanitation must be adhered to, in order to place this food before the consumer in a satisfactory condition. There is room for considerable improvement throughout the meat trade in this connexion. The general method of handling sundries such as tongues, livers, hearts, tails, &c., for the local trade, is often disgusting and calls for immediate improvement.

*B. Inedible Material.*

Many different methods are used in connexion with the disposal of offal and waste products from the various slaughtering units; in most cases these wastes are utilized for the manufacture of manures. in others, animal foods are manufactured from a large precentage of them, the lower qualities only, being utilized in the manufacture of manures. In order that the producers should secure maximum values, an investigation is suggested to determine the best methods for the treatment of these wastes to secure the highest returns. Recently a dry rendering process has been adopted for handling large portions of them in place of treatment by the ordinary digestor method.

## 4. Transportation Problems.

(*a*) *Transport on Land.*

(i) *Fresh Meats.*

Methods employed by some firms engaged in the delivery of local trade meats from meat works to retailers are, to say the least, appalling. Meat, often freshly killed, is thrown in motors or carts in a heap, and one has therefore not to use much imagination to realize its condition on arrival at the retail shops. An appropriate compulsory system for the cartage of export meats from a slaughtering unit to a freezing works, and one that could easily be adopted for local trade, is one that would necessitate the meat being first well chilled, and then carried in clean dust-proof wagons as a swinging load. Where carcass meat is carried by rail from the slaughtering unit to a sales depot or freezing works, it should also be well chilled, and carried as a swinging load in clean railway vans. The question whether these vans should be louvred or closed in is apparently debatable, but it is thought that from a hygienic stand-point, on short runs and provided the meat is well chilled, closed trucks are preferable.

(ii) *Frozen Meats.*

The insulated railway vans at present in use in New South Wales are not always in a good state of repair, with the result that considerable damage is often done to the meats. The ice box at the end of the van fails to cool the whole of the truck, and is more or less useless. It is believed that the Railway Department intends building new vans, and it is understood that Mr. Cramsie, Chairman of the Meat Industry Board, has been in communication

with the Chief Mechanical Engineer of the Railway Department. It is hoped that as a result of such conference, a suitable van will be constructed.

It is suggested, however, that in building such vans the main principles to be considered are—

(i) Facilities for efficient cooling of the truck before loading.

(ii) Efficient insulation of floors, walls and roof.

(iii) Efficient packing of doors.

If these are provided, and if meats are in proper condition when loaded, it is considered that the latter should arrive at the shipside in a satisfactory condition from all Works. It is thought that rapid transit of all meat vans by the Railway Department is absolutely essential, and in general, transportation of stock and meat should be given preference over all other goods trains.

When overseas vessels are loading at berths other than Pyrmont, it is necessary to cart export frozen meats by motor or horse-drawn lorries from Darling Island Railway siding, or from the City Cold Stores to the vessel. This is an objectionable method, but where it is necessary for such carting to be done, as much care as possible is given to the protection of the meats from wind and weather.

(*b*) *Loading Operations and Sea Transport.*

All loading operations of export frozen meat are under the supervision of Commonwealth Inspectors, who see that the temperature and cleanliness of the ship's holds are satisfactory, that the wharfs are clean, that clean slings are used, and that care is taken by stevedores in loading the slings and in the stowage of the meat in the holds. Carcasses that are soft, misshapen, or in any other way unsuitable for export, are rejected and returned to store.

It is suggested that a special wharf, connected by rail, should be constructed for the loading of refrigerated cargoes, and that it be provided with mechanical conveyors. (At Birt and Company's wharf, Jones Bay, there is at present a mechanical loading conveyor, but although installed some few years ago it has not yet been used). Valuable information might be gained if an investigation were made into the better means of loading and stacking carcasses in ships. The present methods of loading in slings, while they have been recently much improved, still leave room for doubt as to whether they are the most efficient and economical for handling such perishable products. Some more economical method—such as an electric conveyor—might be carefully investigated with a view to loading direct from the insulated railway van and placing frozen products direct into the hold of the steamer, thus economizing labour and ensuring that the products are exposed to air temperature for the shortest possible period of time. Speedy loading is essential, as long exposure is likely to prove detrimental to the quality of the product.

(*c*) *Sea Transport.*

Correct stowage and uniform temperatures are essential. An objectionable feature of sea transport is the opening up of hatches at different ports *en route* from the first port of loading. This, of course, in some instances is unavoidable, but Shipping Companies should make every effort to minimize the risk. Numerous instances have arisen where damage to cargoes has occurred, more particularly on ships fitted with the air-cooled system of refrigeration.

(*d*) *Discharge at Destination.*

According to the port of discharge this varies, and may be direct into a cold store at the wharf, or else by rail or barge, &c., to cold stores for final distribution to markets. The preferable method, however, is direct from the steamers into cold storage accommodation at the wharfs.

## 5. De-frosting.

In connexion with the disposal of frozen meats,. it is suggested that suitable experiments in connexion with de-frosting might be carried out with beneficial results to the meat trade of Australia. It being necessary for Australia to ship frozen beef to Great Britain or the other markets of the world, an investigation should be made to learn whether it is possible to secure an economical and efficient method of de-frosting beef before placing that material before the consuming public. Many cases have been known where the purchaser of frozen beef has failed to de-frost the meat properly before attempting to cook it, with the result that its use has created a bad impression. Chilled beef being much easier to handle in the ordinary household, naturally commands more attention from the consuming public, and will continue to do so until such time as we are able to de-frost our beef efficiently and economically. An improved process will prevent mistakes being made in the kitchen, and will give the marketed product a better appearance. An electric process for de-frosting beef was patented in Victoria some few years ago, and we understand demonstrations gave good results, but so far it has not been generally applied in commercial operations.

## 6. Recommendations.

(*a*) That a Cattle Breeding Experiment Station be established in Northern Australia to determine the most suitable of the recognized British breeds for our tropical areas, and to ascertain whether it is possible by crossing them with Asiatic breeds, to elaborate a still more profitable beef producer for these areas. Hornless might also be compared with horned breeds.

(*b*) That arrangements be made with some of the Agricultural Colleges for the experimental fattening of cattle by hand-feeding, to ascertain to what extent it can be profitably adopted by farmers. Improved methods of fattening pigs might also be considered.

(*c*) That research be expedited in connexion with the many problems associated with the chilling and freezing of meat and methods of storage. The research being carried out by the Meat Freezing Committee of the Australian National Research Council is greatly appreciated by the Industry and its encouragement is strongly urged.

(*d*) That experiments be carried out to definitely settle the question as to whether cold pickle is superior to hot pickle. At the present time contracts are let both ways, and it is highly desirable for the benefit of the Industry that the advantages (if any) of one method over the other should be determined.

(*e*) That an investigation be carried out to ascertain the best and most profitable methods for the treatment of offal and waste products of slaughtering units. Many of the methods now employed are economically unsound, and scientific direction is badly needed.

(*f*) That representation be made by the Council to the Harbour Trust as to the desirability of installing modern methods of loading frozen meat in order to obviate the loss of time, the high cost of handling, and the deterioration of meat, incurred under the existing method. The opinion is expressed that considerable improvement could be effected without much difficulty.

(*g*) That research on the de-frosting of meat be stimulated to the highest degree, as improvement in the process will confer much benefit upon both the producer and consumer.

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# Mineral Deficiencies of Pastures.

*Memorandum prepared for the purposes of the Imperial Agricultural Research Conference* (1927) *by Professor A. E. V. Richardson, Director, Waite Agricultural Research Institute, University of Adelaide.*

## Introduction.

The greater portion of the sheep and cattle of the Empire are maintained entirely on natural pastures. Any improvement in the stock-carrying capacity of either the natural or cultivated pastures of the Home country, or of the Dominions, would affect the material wealth of the whole Empire, but problems associated with pasture improvement are of special importance to Australia, South Africa, and New Zealand.

Comparatively little work has been done on the nutritive value and composition of natural or seeded pastures, but recently facts of great importance in connexion with the influence of certain constituents in such grass lands have been brought to light. Over widespread areas within the Empire the occurrence of malnutrition of stock is common In some cases the pathological conditions are of a specific type and occur in well-defined regions. Thus Theiler and his associates (*Journal of the Department of Agriculture, South Africa,* May, 1924), in South Africa have shown that styfsiekte in cattle is caused by a phosphorus deficiency in the soil and in the vegetation. They have also found that the veld soils on which this phenomenon occurs are very low in phosphorus, and that, in consequence, the level of phosphorus in the vegetation is below the physiological optimum requirements of the cattle.

Bush sickness, a condition characterized by anaemia and emaciation, is found in the North Island of New Zealand, and the cause of the malnutrition is stated by Aston (*Transactions of the New Zealand Institute,* 55, 720), to be due to deficiency of iron. Davis (*Journal of Agriculture, India,* 22, 77) has drawn attention to the very low milk yield of cattle

in the Bihar district of India, and has correlated it with a low percentage of phosphorus in the crops and soils of the State. Munro (*Report on Falkland Islands,* 1924) has drawn attention to the high mortality amongst sheep in the Falkland Islands, and Godden (*Journal of Agricultural Science,* Vol. XVI., Pt. 1) has shown that the pastures of the Falkland Islands are very low in both lime and phosphorus, as compared with the average cultivated pastures of England.

Similar cases of malnutrition have been recorded in the south of Scotland by McGowan (*Scottish Journal of Agriculture,* Vol. 5, p. 274), and, in Australia, by Henry (*New South Wales Department of Agriculture, Science Bulletin* 12).

The general symptoms reported as occurring in parts of the Dominions and Colonies are the slow rate of growth, high mortality, low milk yield in cows, and low birth-rate. In most of the cases the animals suffer from an abnormal craving for certain inorganic substances. A number of causes contribute to these various nutritional troubles. In many cases, however, it seems certain that the chief cause of malnutrition is a deficiency of essential mineral elements in the pasture. Chemical analyses show that the soils and pastures in the areas where malnutrition occurs have an abnormally low content of one or more of these elements, and that by supplying these deficient minerals in the diet, a marked improvement in the rate of growth of the animals has resulted.

Important investigations have been conducted at the Rowett Institute, Aberdeen, and these have shown that, while there is no striking difference in the energy value between good and poor pastures, there are wide variations in the proportions in which the mineral constituents are present in rich and poor pastures. It has also been shown that the differences in the mineral content of pastures correspond closely with the value of the pasture, a high mineral content being associated with a high nutritive value. The demonstration that the mineral constituents of the pasture is of an importance at least equal to the energy yielding constituents, opens up possibilities of a very far-reaching kind, both economic and scientific.

## Investigations in Australia.

The Empire Marketing Board and the Council for Scientific and Industrial Research are co-operating with the University of Adelaide in the investigation of the mineral deficiencies of pastures in Australia. These investigations will be conducted in close collaboration with the Rowett Research Institute, Aberdeen, and with the investigations on animal nutrition conducted by the Council already mentioned.

The general object of the investigations at the Waite Institute will be to determine the role of the various mineral nutrients on the growth, development, and nutritive value of pastures, indigenous and exotic in Australia; to study the relation of soil deficiencies to the composition of the pasture; and to determine how far observed differences in the nutritive value of native and seeded pastures may be correlated with the mineral composition of the pasture plants.

Special attention will at first be devoted to the effect of deficiencies of phosphorus and calcium on pastures because of the large areas of territory which are notably deficient in these constituents, but an investigation will also be made of the effect of all mineral nutrients on the

nutritive value of the herbage. In view of the special significance of rainfall to pasture production over large areas of Australia and South Africa, the relationship between mineral intake of nutrients of typical pasture plants to the rate of photosynthesis and transpiration, will be determined. A chemical analysis of pastures at varying stages of growth, and after rain and drought, in representative areas will be made to determine whether, and to what extent, the pastures are deficient in mineral elements.

The investigations will be conducted in the field, pot culture house, and laboratory. For the first season the field investigations will be confined mainly to the influence of various forms of phosphates and calcium on (*a*) the yield of herbage; (*b*) botanical composition of the pasture; (*c*) chemical composition of the pasture at varying stages of growth; and (*d*) nutritive and grazing value of the pasture. Special attention will be given to the effect of cutting and grazing on the growth and development of individual species in natural pastures.

In the pot culture house an investigation will be made of the mineral intake of typical native and introduced pasture plants throughout the period of growth, raised under varying conditions as regards (*a*) moisture content of soil to represent variations in rainfall; and (*b*) mineral deficiency and mineral excess.

The laboratory work will comprise the analyses of herbage and pasture plants from field trials, pot culture tests, and water culture tests for proximate constituents and mineral nutrients.

A certain number of analyses of soils will be undertaken to show the relationship between the composition of the soil and that of the pasture grown on the soil. Grazing tests on pastures treated with varying fertilizers will also be conducted to determine how far the results obtained by grazing may be correlated with weight and composition of herbage.

# The Commonwealth Research Station, Murrumbidgee Irrigation Areas.

*By E. S. West, M.Sc., Officer in Charge of the Station.*



## 1. General.

The Commonwealth Research Station, Griffith, was officially opened on the 4th September, 1924, by Mr. Commissioner Evatt, of the Water Conservation and Irrigation Commission of New South Wales. It was established jointly by the Commission and the former Commonwealth Institute of Science and Industry, and for the purpose of studying irrigation problems. As first established, the Station was controlled by a Committee of three, consisting of a representative from each of the contributing bodies and a settlers' representative; and as it was intended at that stage to devote attention mainly to problems of the citrus industry, the Station was established under the name of the Commonwealth Citrus Research Station.

With the re-organization of the Commonwealth Institute of Science and Industry, which resulted in the formation of the Council for Scientific and Industrial Research, the control of the Station was taken over by the latter, which has assumed full financial responsibility. The Water Conservation and Irrigation Commission of New South Wales still assists financially in the prosecution of the work by means of an annual subsidy. As it is not now intended to limit the scope of the work to citrus investigations, the name of the Station has been changed to the Commonwealth Research Station, Murrumbidgee Irrigation Areas. The Station is centrally situated 3 miles from the town of Griffith, on the Murrumbidgee Irrigation Areas, New South Wales, and comprises 57 acres, of which 50 are irrigable. Other horticultural land is available for possible future extension, in addition to a large area suitable for rice investigations, should such be undertaken.

## 2. Original Field Experiments.

The original field experiments laid down were designed to yield information concerning the following problems, viz.:—

(i) The effect of different soil treatment on the structure, yielding capacity, and other properties of the soil.

(ii) The most profitable fertilizer treatment for citrus fruit under local conditions.

(iii) The effect on soil and citrus trees of various methods of green manuring.

(iv) Bud selection studies.

Experiments designed to elucidate these problems are embodied in the three main experimental fields mentioned in the sections that follow.

## 3. Soil Treatment Field (Field 100).

This field is designed for the study of the effect of various soil treatments on the fertility of the soil, and on the percolation of water through it.

Where irrigation is practised the soil is called upon to absorb anything from 2 to 6 acre-inches per acre or, at times, even greater amounts than this, during a single irrigation. Under dry conditions the soil seldom receives such large amounts of water, a fall of even 3 inches being phenomenal and leading to floods. It is only to be expected, then, that the large applications of water made under irrigation should create problems more or less foreign to the dry farmer, and it is these problems related to the soil which become the most important in irrigation areas. Improper use of water may lead to the creation of a high water table, with the disastrous results illustrated in Fig. 1,* which shows the limited root development of an orange tree growing in water-logged soil. Trees with such a shallow root system as this inevitably die when mature, as the roots fail to cope with the transpiration demands of the green portions.

Prior to planting, Field 100 was poorly drained, and owing to the rather heavy texture of the soil semi-marsh conditions prevailed. It was therefore an excellent site for the proposed studies. It is now planted with Washington Navel orange trees, and is divided up into plots 1 chain wide, some of which have been deep-ploughed to a depth of 24 inches (sod turned), others deep-knifed to a depth of 24 inches (sod unturned), others dressed with applications of lime of from ½ to 4 tons per acre, and others dressed with applications of gypsum of from ½ to 4 tons per acre.

The field is divided into two divisions, plots of the above treatments occurring on each, but in addition tile drains are laid below the plots of one division, the other division remaining undrained.

Both lime and gypsum are well-known soil amendments, both floculating the clay fraction of soils, thus making the latter more pervious to water. The deep-knifing is equivalent to subsoiling, while the deep-ploughing brings up the lime, which is usually found at a depth of 18 inches in the soil (zone of deposition), and mixes it with the surface soil. This treatment is equivalent to a dressing of about 30 tons of limestone per acre, and it greatly improves the physical condition of the soil, particularly in the latter's permeability to water. It is found that deep-knifing and the application of gypsum also increases the permeability of the soil to water, but the deep-knifing does not appear to be so permanent in its effect as the deep-ploughing. Very little effect from liming has been noted on this soil.

In order to study the effect of these treatments on the percolation of water through the soil, a comprehensive series of "test wells," which consist essentially of lengths of perforated downpipe 6 feet long and 2 inches in diameter, introduced into the soil, have been constructed over the field. These "test wells" are placed 22 feet apart in rows 66 feet apart, running across the lines of tile drains, and the height of the water in them, measured by a graduated wooden rod, indicates the depth to the saturated soil.

Fig. 2 illustrates the way in which the fall of the water table in the soil is affected by the tile drains, as shown by data obtained from this source. A self-registering test well has also been installed which, by means of a float and recording mechanism, continually records the height of the water table. By means of a barograph it can readily be demonstrated that with a fall in the atmospheric pressure the water table rises, and vice versa.

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* See Plate 4, facing page 122.

In order to study further the downward movement of the water through the soil after irrigation, concrete-lined wells have been sunk in two different localities on the Station. At successive depths brass tubes pass through the concrete, and a length of glass tubing bent up at right angles is introduced into each brass tube. If any free water is present in the soil water will rise in the tube, the height of the water corresponding to its hydrostatic pressure. In this way, a method is afforded of studying the downward percolation of the waves of saturation created by irrigations. It is important to know how far water percolates through the soil, as if too little is added it will not wet the soil to the full root zone, while on the other hand excessive applications lead to the percolation of water beyond the root zone, which not only represents a waste, but may result in the menace of a high water table.

Studies on this field have shown that it is possible for the water table in certain localities on the Murrumbidgee areas to rise from great depths to the surface, and that after but a comparatively few years of improper irrigation. It is not meant by this that there is a likelihood of the water table rising over large areas; but there are areas of five to ten or more acres where the water table has already risen to the surface, creating serious local problems.

### 4. Fertilizer Field (Field 200).

A knowledge of the fertilizers required for maximum returns is very essential in the commercial culture of any crop, and especially in the case of such intense farming as citriculture. In order to obtain data on this question a permanent fertilizer experiment was laid down. This field (200), planted with citrus trees, has been divided into plots receiving annual dressings of fertilizers as follows:—

(i) Nitrogen plus potash plus phosphoric acid.
(ii) Nitrogen plus potash.
(iii) Nitrogen plus phosphoric acid.
(iv) Potash plus phosphoric acid.
(v) Phosphoric acid.
(vi) Potash.
(vii) Nitrogen.
(viii) Untreated.

The nitrogen is applied as sulphate of ammonia, the potash as sulphate of potash, and the phosphoric acid as superphosphate.

This experiment is designed to determine the fertilizing elements required under local conditions, and a study of the foregoing treatments will reveal the fact that the reaction of the trees to each fertilizer will become manifest by the experiment. Thus if, for example, nitrogen alone is required, the trees will respond to treatments 1, 2, 3 and 7, while if both nitrogen and phosphoric acid are necessary only plots 1 and 3 will show increased yields. The plots are replicated four times to overcome soil and plant variability.

### 5. Green Manure Field (Field 300).

This field is laid down to a permanent green manure treatment. Five treatments are being investigated as follows:—

(i) Summer green manure crop (Cowpease).
(ii) Winter green manure crop (Tick beans).

(iii) Biennial green manure crop (Bokhara clover).
(iv) Perennial green manure crop (Lucerne).
(v) Continuous clean culture.

The crop in brackets indicates the crop at present being used; but other crops may be substituted in future years, if thought desirable from a practical point of view. For example, soya beans or some other summer green crop may be used in lieu of cowpease, and field pease in lieu of tick beans.

The necessity for green manures under orchard conditions, particularly on semi-arid soils, and where it is not economically possible to use other organic manures, is undisputed. However, the best method of green manuring, especially in citrus orchards, is a point requiring investigation, as there are advantages and disadvantages in the use of both summer and winter-growing crops, while Bokhara clover, though being specially valuable in opening up heavy soils on account of its long thick roots, is a biennial, and therefore seriously competes with the tree.

*Inter alia*, it is expected that this experiment will yield data as to the effect of the various green manure treatments on:—

(i) The yield.
(ii) The chemical, physical and biological conditions of the soil such as humus content, nitrogen content and availability of other fertilizing elements, permeability of surface and of subsoil, structure and ease of working, capillarity and water-holding capacity, and other properties related to the colloidal content of the soil.
(iii) Such physiological troubles as summer drop of the fruit, and various other physiological conditions of the trees.
(iv) Duty of water, &c.

The trees are only young as yet, but so far those in the winter green manure plots appear to be making the best growth.

## 6. Bud Selection.

The importance of bud selection in the propagation of citrus trees has long been recognized and has been abundantly demonstrated by the extensive classical work of Shamel and his co-workers. It is especially important in the case of citrus fruit, owing to the particular susceptibility of that genus to the production of bud mutations, manifest in the very common occurrence of fruit of different types growing on the same tree, and in the frequent appearance of chimeras.

Nursery trees have been worked with buds taken from selected trees with a good record growing in the Murrumbidgee Irrigation Areas, in the coastal districts of New South Wales, and in the Murray Settlements; and the trees so raised have been planted out at the Research Station. This will enable a distinction to be drawn between germinal variations (mutations), and somatic variations (modifications) which are merely due to difference in soil, climate, or age of the tree, and are of no importance from the point of view of new propagations. Without such a test as this it is sometimes difficult in practice to distinguish between true mutations and mere modifications.

The location of several other good type Washington Navel trees has been recorded, and settlers requiring buds to raise nursery stock or bud over off-type trees are advised of the location of these to enable

them to secure buds which may reasonably be expected to produce good type trees. In this way trees yielding off-type fruit are gradually being eliminated, resulting in an improvement of the citrus pack.

### 7. Soil Survey.

As part of the general scheme of soil surveys of Australian irrigation areas, it is proposed to undertake a detailed soil survey of the Murrumbidgee Irrigation Area, and in order to provide for this work a fully-equipped laboratory is being included in the new buildings being erected at the Station. The survey will be undertaken in close co-operation with the Waite Institute of South Australia.

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# The Science and Industry Endowment Fund.

### 1. General.

In June, 1926, the Commonwealth Government passed two Acts of outstanding importance to scientific work in Australia. One—the *Science and Industry Research Act* 1920-26—reorganized the former Institute of Science and Industry and constituted the Council for Scientific and Industrial Research. The other—the *Science and Industry Endowment Act* 1926—appropriated a sum of £100,000 from the Consolidated Revenue, and provided that the interest on this amount shall be used for the purpose of granting assistance—

(*a*) to persons engaged in scientific research; and
(*b*) in the training of students in scientific research.

The latter Act created the Science and Industry Endowment Fund, which consists of (i) the amount appropriated by the Act, and of income derived from the investment of that amount or any part thereof; and (ii) gifts or bequests given or made for the purposes of the Fund and the income derived from or proceeds of the realization of the property so given or devised. The Fund is vested in and placed under the control of Trustees who are the members for the time being of the Executive Committee of the Commonwealth Council for Scientific and Industrial Research.

The Trustees have now had several meetings, and have laid down a few general rules for their own guidance and for the information of research workers generally. Full details of these are given in a pamphlet[1] issued by the Trustees early in 1927.

The present income of the Fund is in the neighbourhood of £5,000 per annum, and it is not anticipated that it will change very much from that amount unless gifts or bequests are made to the capital of the Fund. Provision is made in the Act for such gifts, and the Trustees are empowered to deal with the income derived from any gift in accordance with any conditions that may be laid down by the donor.

### 2. Present Intentions of the Trustees.

Attention has been drawn on many occasions to Australia's lack of research workers trained in certain branches of science which are of particular importance from the point of view of the solution of

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(1) Available on application to the Secretary, 314 Albert-street, East Melbourne.

many national problems. Sir Frank Heath, the late Secretary of the British Department of Scientific and Industrial Research, drew attention to this matter during his visit to Australia in the latter half of the year 1925. The forecast that was made on that occasion has been amply borne out by the subsequent experience of the Council. In the fields of entomology, plant pathology, food preservation, tropical agriculture, and certain other branches of science, the main obstacle in the way of development of the Council's activities is the lack of trained scientific workers.

In an endeavour to remedy the above conditions, the Trustees intend during the early years of their operations to devote the funds available to them chiefly to the purpose of training research workers. At present it is anticipated that about four-fifths of the annual income of the Endowment Fund, i.e., £4,000 per annum, may very properly be applied to this end, and that the remaining one-fifth, i.e., about £1,000 per annum, may be devoted to the assistance of workers already engaged in research.

### 3. The Training of Research Students.

The Trustees have initiated a system of Research Studentships. These are tenable by distinguished honours graduates of Australian Universities or Technical Colleges who have proved to the satisfaction of their professors or other supervisors that they are capable of taking full advantage of an opportunity for intensive training in scientific research. As a rule such studentships are held abroad, but the Trustees do not wish to debar themselves from choosing an Australian University or other institution as a field of training.

The studentships are tenable for two years, and carry an allowance of £300 per annum, together with such additional allowances for travelling fares outwards and homewards as may be required. It is estimated that on the average £150 will cover the latter, so that the annual cost of a student will be about £375, or, say, £400, after allowing for any special expenses (fees, travelling, &c.) incurred while abroad, and not rightly chargeable as personal expenses. The expenditure of £4,000 per annum will thus permit the maintenance of ten students abroad. Students are required to give the Council an option upon their services for the three years subsequent to their return to the Commonwealth, at salaries of £400 for the first year, £450 for the second, and £500 for the third year.

### 4. The Assistance of Persons Engaged in Scientific Research.

The Trustees have about £1,000 per annum available for the assistance of persons engaged in scientific work; but in the course of time the pressing need to send students abroad for training may abate, in which case further funds would be available for the other main object of the fund. It is hoped, too, that public and private benefactions will materially add to the sum annually available for this purpose.

For the present the Trustees have decided to follow somewhat closely the lines which have been proved satisfactory by the British Department of Scientific and Industrial Research, and to invite applications for grants for any of the three following objects:—

(i) To provide personal payments to investigators to enable them to give whole or part time to a research conducted independently or in collaboration with a professor or person interested in the development of such research.

(ii) To provide laboratory, clerical, or other assistance to persons engaged in research.

(iii) To provide grants for special equipment and other special expenses incidental to research.

In no case will the Trustees entertain applications for assistance when, in their opinion, such assistance should be provided by existing institutions. Thus, they will not consider applications for personal payments to members of the staffs of Universities or other institutions having research as one of their functions, holding, with the British Advisory Council, that "research, no less than teaching, is a primary function of these institutions, and the salaries attaching to posts on their staffs ought to be sufficient to enable the holders to devote a reasonable proportion of their time to the advancement of knowledge within their respective departments." Nor will they provide technical or clerical assistance of a general kind in a research laboratory, or apparatus which should be part of the normal equipment of a laboratory used for teaching purposes.

Applications should preferably be made by the 1st November in any year, so that decisions may be announced well before the commencement of the next academic year.

Personal payments will be made only to investigators of proved powers to enable them to devote to some specific research time which would otherwise be given to paid work. Preference will also be given to persons whose careers lie in research work. It is not intended, for example, to assist persons who are seeking research degrees as avenues to employment which will not include research.

### 5. Appointments to Research Studentships already Made.

A few appointments to Research Studentships have already been made. In April, 1926, applications were called for two studentships in "food preservation, especially cold storage," one in "forests products," and one in "liquid fuels." Shortly after, nominations were asked for in regard to studentships in "fruit preservation," "economic entomology," "forest entomology," "forest mycology," and "general forest products work." As a result, the following research students have been appointed:—

*L. J. Rogers, B.E.*, a graduate of the University of Western Australia. He left Australia in August, 1926, for the Fuel Research Station (Greenwich) of the British Department of Scientific and Industrial Research. While there he will become conversant with the Fuel Research Board's work on the low temperature distillation of coal, on the Bergius process, and on other investigations aimed at the development of a process for the commercial production of a substitute for petrol.

*J. R. Duggan, B.Sc., B.E.*, a graduate of the University of Sydney. He left Australia in November, 1926, for the Fuel Research Station, Greenwich, where he is undergoing a training similar to that mentioned in the case of Mr. Rogers.

*F. G. Holdaway, M.Sc.*, a graduate of the University of Queensland and late Assistant-Lecturer in Zoology, University of Adelaide. He left Australia in September, 1926, for Cornell University, where he is undergoing post-graduate training on general entomological problems. On his return to Australia he will probably specialize on economic entomology.

*S. Garthside, B.Sc.Agr.*, a graduate of the University of Sydney. He left Australia in October, 1926, for Cornell University, where he is undergoing a very similar training to that mentioned in the case of Mr. Holdaway.

*H. E. Dadswell, B.Sc.*, a science graduate in chemistry (University of Sydney). He left Australia in November, 1926, for the Forest Products Laboratory at Madison, Wisconsin, United States of America, and is specializing on forest products research.

*J. E. Cummins, B.Sc.*, a graduate of the University of Western Australia. He left Australia in January, 1927, for the Forest Products Laboratory, Madison. Prior to leaving, he was an officer of the Western Australian Forests Department. He is undergoing a training similar to that of Mr. Dadswell.

*J. W. Evans, B.A.*, a graduate of the University of Cambridge, has been domiciled in Australia for some time. Early in 1927 he left for New Zealand, where he is now obtaining further experience in economic entomology under Dr. R. J. Tillyard, of the Cawthron Institute.

All the above seven investigators have been appointed to full studentships. In addition, the Trustees have given small grants to two research workers who had made arrangements to obtain experience and training abroad prior to the inauguration of the Endowment Fund. These two workers are as follow:—

*J. R. Vickery, M.Sc.*, a graduate of the University of Melbourne in Biochemistry. In July, 1926, he left Australia for Cambridge University on an 1851 Exhibition. He is now engaged on a fundamental investigation of the changes in osmotic pressure of mammalian muscle at low temperatures. In addition, he is carrying out one or two special researches of a more technical nature, and is located at the Cambridge Low Temperature Research Station of the British Food Investigation Board.

*H. W. Strong, M.Sc.*, a graduate of the University of Melbourne in chemistry. He left Australia in August, 1926, for a course of further training in the technology of fuels. He is now located at the Imperial College of Science and Technology, London, where he is working under Professor W. A. Bone.

In June, 1927, the Trustees called for applications for full studentships in entomology, cold storage work, tropical agriculture, agrostology, and plant pathology. The following investigator has been appointed and will leave Australia in the near future:—

*Miss Phyllis Jarrett, B.Sc.*, a graduate in Botany of the University of Melbourne. Arrangements are being made for her to obtain further training in plant pathology at the Rothamsted Agricultural Research Institute, England.

In conclusion, the Trustees are desirous of expressing their very cordial thanks to the authorities of the research institutions mentioned above as having been agreeable to give further training to Australian students. It is obvious that without this kind and valuable co-operation the whole scheme of training described in the foregoing would be very severely handicapped.

# The Export of Fruit from South Africa.

*By Dr. W. J. Young, Associate-Professor of Biochemistry, University of Melbourne.*

As a preliminary to its consideration of a programme of cold storage research, the Council arranged for Dr. W. J. Young to proceed to South Africa in order that he might meet Dr. Franklin Kidd and Mrs. Kidd, and make inquiries with these two officers of the British Food Investigation Board into the methods adopted by the flourishing South African fruit export industry. Dr. Young has now furnished the following report of his visit.—Ed.



## 1. Introduction.

The chief exports of perishable products from South Africa are fruit and eggs. In addition, a small but increasing amount of meat is exported in the frozen condition, but this is of very poor quality and quite unsuitable for the English market, and is sent to Italy. The export of frozen and of chilled beef, mainly from Rhodesia, is proposed from Walfisch Bay, in South-west Africa, as soon as railway communication is completed.

The following report, therefore, is restricted to fruit, and gives a general account of the fruit export from the Union, and of the research work being carried on in connexion with the industry. The data was collected during a visit to South Africa in January and February, 1927, in conjunction with Dr. and Mrs. Franklin Kidd, of the Low Temperature Research Station, of Cambridge.

The following places were visited, and the growing, packing, cool storage, and transport of fruit were investigated in these districts, viz., Western Cape Province; Eastern Cape Province, in the neighbourhoods of Cookhouse, Port Elizabeth, and Grahamstown; the Transvaal round Pretoria and Johannesburg; Natal, in the Durban district.

On account of the season of the year, deciduous fruits only were actually seen in process of packing and exporting, but citrus orchards were visited in all the Provinces, and information collected as to the methods employed with these fruits. Pineapples were seen growing in the Bathurst district (East Cape Province), and the pineapple canning factory of the South African Canning and Packing Company visited in Port Elizabeth. Dried fruit factories were inspected at Cookhouse (dried apricots), and at Wellington and Worcester (dried apricots, pears, prunes, and a few raisins). At Cookhouse, the Golden Valley Estates have over 500,000 apricot trees under irrigation, and the fruit is dried in the district, where there are two dehydrating plants, one owned by the Golden Valley Estates Company, and the other by a co-operative company.

Throughout the visit, the greatest hospitality was experienced from every one connected with the growing and export of fruit. all information was freely given, and a strong desire was expressed by all for full co-operation in research between Australia and South Africa. It is desired here especially to thank Dr. I. B. Pole-Evans.

Chief of the Division of Botany and Horticulture, and Mr. E. A. Griffiths, Director of the Low Temperature Research Laboratories, Cape Town.

## 2. Fruit Growing Areas of the Union of South Africa.

*Deciduous Fruits (Pears, Peaches, Grapes, Plums, &c.)*.—The largest proportion of these fruits exported is grown in the western districts of the Cape Province, but deciduous fruits are also grown in the Eastern Cape Province round Mossel Bay, and in the neighbourhood of Grahamstown and Port Elizabeth; in the Transvaal round Johannesburg, Pretoria, Rustenburg, and Magaliesburg; in parts of Natal; and a small quantity in the Orange Free State. The climatic conditions in these districts show very considerable differences. Thus, in the southern parts of the Cape Province, the rains fall mainly in the winter months; in the northern parts, the Transvaal, Natal, and the Orange Free State, the chief rains are in the summer; whilst in the districts in the Cape Province round Grahamstown, the rains are more evenly distributed throughout the year.

*Citrus Fruit* is grown in the Transvaal, in the Pretoria, Rustenburg, and St. Petersburg districts, and in Natal, all with summer rains. It is also grown in the Eastern Cape Province, and, to a small extent, in the Western Cape Province, at Clan William. In these districts the rains fall mainly in the winter during the picking season.

*Pineapples* are grown largely in Natal, and in the Bathurst district of the Eastern Cape Province.

About 30 per cent. of the fruit produced in the Union is grown under irrigation.

The following table gives the quantities of the various non-citrus fruits exported during 1925-1926:—

| Variety of Fruit. | Number of Trays Exported. |
|---|---|
| Pears | 888,263 |
| Grapes | 355,624 |
| Peaches | 156,255 |
| Plums | 129,398 |
| Nectarines | 17,010 |
| Apricots | 8,295 |
| Apples | 8,074 |
| Pines | 48,962 |
| Other fruits | 6,124 |
| | 1,618,705 |

Of this total, 52,121 trays were packed and pre-cooled in the Transvaal, and railed 1,000 miles in refrigerator cars. In 1926, over 700,000 boxes of citrus fruits were exported, approximately two-thirds of this being grown in the Transvaal.

## 3. Picking, Grading, and Packing.

The actual work of picking, grading, and packing is done by native or half-caste labour under the supervision of white overseers.

Deciduous fruits are graded according to size and variety, and packed on the farms, the conditions of grading and packing being laid down in the regulations of the fruit export, &c. Each fruit is wrapped

in paper, and packed in "wood-wool" in trays, 18 inches by 12 inches, or 18 inches by 24 inches, with varying depths, each tray holding one layer of fruit. Grapes are packed in similar trays, each bunch being wrapped in paper, and packed in "wood-wool" in a single layer. Apples and citrus fruit may, however, be packed in larger cases ($1\frac{1}{3}$ bushels). Each grower has a distinctive mark on the boxes, and the latter are nailed up with $\frac{1}{2}$-inch cleats at each end, these cleats being coloured to mark the different kinds of fruit. Very few apples are exported overseas. Apples were seen in the Transvaal being packed for transport to Rhodesia, and these were wrapped in paper, and packed in "wood-wool" in a single layer in trays.

Before packing pears are carefully cleaned from the arsenate spray. In some cases this is done by wiping with a cloth, but a mechanical process of washing the fruit with hydrochloric acid (0.5 per cent.) is now being generally adopted. This procedure is followed because of the restrictions in Great Britain on the sale of fruit containing more than a certain percentage of arsenic. At present, samples from every batch of pears are analyzed by the Government Analyst at Cape Town, and the consignment held in cold store until the results are known and shown to be within the prescribed limit.

Citrus fruit is often packed in co-operative packing sheds. This fruit is seldom sweated, but in a large citrus orchard at Zebedela, near St. Petersburg, now coming into bearing, a large plant has been installed for treating the fruit by the Brogdex borax method.

### 4. Transport.

Most of the fruit exported from South Africa is shipped from Cape Town, where there is a large new pre-cooling station (details later), but a considerable amount, especially of citrus fruit, goes from Durban and Port Elizabeth. Deciduous fruit from the Western Province, where the main quantity is grown, is railed to Cape Town in ventilated trucks, the journey occupying usually one night. The fruit is inspected, and put into the pre-cooling station, from which it is subsequently transferred to the ships. The Transvaal deciduous fruit is taken to Johannesburg where it is inspected and cooled down in the cold store of the "Rand Cold Storage and Supply Company Limited," by arrangement with the Government. It is then loaded into special refrigerator railway trucks, which will be described later, and brought to Cape Town (1,000 miles). Here, if the temperature is reasonably low, and a ship immediately available, it may go direct into the ship's hold after inspection. Usually, however, it is stored in the pre-cooler at the wharf until the ship's arrival.

Citrus fruit ripening in the winter is carried in louvred trucks without ice. Even from the Transvaal, no ice trucks are required; indeed, some damage is done through frosts, which are very severe in the high lands over which the railway passes in the journey from the Transvaal to Cape Town. The fruit on arrival undergoes inspection, and is pre-cooled before shipping.

In Durban a small quantity of fruit, mainly pineapples, is shipped without cooling, but if much fruit is being exported, as in the citrus season, it is taken out to Congella, some way from the docks, cooled in a privately-owned cold store, and transported to the docks in refrigerator railway trucks. It is proposed to build a pre-cooling station in Durban on the docks, thereby saving a considerable amount of handling.

At Port Elizabeth, there is no wharf available for overseas boats, and these have to anchor under shelter of a breakwater, and are loaded from lighters. Refrigerator lighters are now being successfully employed to carry the fruit out to the boats.

### 5. Inspection.

All fruit undergoes inspection before being pre-cooled and shipped. A staff of inspectors is employed for this purpose under the Botanical and Horticultural Division of the Department of Agriculture. The Chief Inspector, Mr. V. A. Putterill, is a scientifically trained man, a University graduate. He was sent by the Government to Cambridge, where he spent eighteen months at the Low Temperature Research Laboratory. Inspectors are stationed at all ports, and at Johannesburg. Five per cent. of each grade of fruit is opened, and if this prove defective, a further 5 per cent. is examined. The inspector has the power to re-grade the fruit, or to reject it for export.

This inspection costs the grower 5s. a ton of fruit (cubic measure), or about 1d. per tray for deciduous fruit, and 4d. a case for citrus. The cost to the grower of the pre-cooling is 5s. a ton, or about 1d. per tray for deciduous fruit and 4d. per case for citrus fruit. A further charge of 5s. 6d. a ton is made for handling.

### 6. Co-operative Societies and Fruit Control.

Local co-operative societies are formed of the fruit-growers in each district. They are authorized by Act of Parliament, and their duties consist in supplying packing materials, manures, &c., used in the industry; in providing, in some districts, co-operative packing sheds; in selecting representatives for the co-operative exchange; in nominating representatives for the Perishable Products Export Control Board; and negotiating loans and mortgages. They are authorized to collect a levy from each exporter of 5s. for every ton of fruit, this sum being portioned out between the Co-operative Fruit Exchange and the Control Board.

The Central body, the Co-operative Fruit Exchange, consists of two divisions, the Citrus Fruit Exchange, and the Deciduous Fruit Exchange. This body co-ordinates the work of the co-operative societies, arranges shipments with the shipping agents, and proposes in future to appoint an agent in London to whom fruit will be consigned, and who will deal with the marketing.

The Perishable Products Export Control Board is a Government body consisting at present of six members. Three are appointed by the Governor-General and are whole-time officers. One of these is appointed chairman, and has a casting vote. The other three consist of one representative of each of the three industries, namely, citrus fruits, deciduous fruits, and the egg and poultry industry. These members are nominated by the industries they represent through the Minister of Agriculture, and are appointed by the Governor-General. The Act provides for the addition to the representative members of one representative for any other kind of perishable produce, should the export reach a sufficient quantity to justify such an appointment. The duties of the Control Board are to control export, to obtain estimates from the growers as to what shipping accommodation they will require, to make provision with

the shipping companies for shipping space, and to allot shipping accommodation in order of priority of arrival of the produce at the port. Should an exporter fail to export at least three-fourths of the quantity which he has previously estimated, and if arrangements cannot be made otherwise to fill the shipping space retained for him, the Board has the power to charge him for such space.

The expenditure of the Control Board is met from the levy made from the growers, and which is collected by the co-operative societies, but the Minister of Agriculture has the power of making a special levy on the tonnage exported of any perishable material on which a levy is not at the time being made.

The Perishable Products Board employs an executive officer (Mr. G. C. Hobson), who has complete control of all transport and handling from the receiving station to the ship. He is responsible for the unloading from the trains on to the skids, arranges space in the pre-cooling station, and supervises the loading into the ship's hold.

### 7. Research Work.

(i) *On Production.*—Practically no work of a systematic kind is being carried out on production.

(ii) *Pests and Diseases.*—The Division of Botany and Horticulture is carrying out, in the laboratories at Pretoria and Durban, and in the field in various parts of South Africa, a certain amount of work on the eradication of pests, and on the diseases of fruit trees. A good deal of work has already been published on citrus canker, and on bacterial and fungus diseases of citrus fruit.

A notable result was the very drastic procedure put into operation for the eradication of citrus canker, which appeared in the Transvaal a few years ago. The measures employed apparently proved effective, since no case of canker has been observed for some time. The Division has a small orchard in the Transvaal set apart for experimental work on diseases of citrus trees.

(iii) *Transport and Storage.*—Nearly three years ago the South African Government secured the services of Mr. E. A. Griffiths, who had previously worked for the Food Investigation Board of the British Department of Scientific and Industrial Research, to organize an experimental station, and to investigate the export of fruit from South Africa. Under his direction the present organization has been built up, and the Low Temperature Research Laboratories were formally opened in Cape Town in February, 1927, during our visit to South Africa.

The Low Temperature Research Laboratory is a branch of the Division of Botany and Horticulture of the Department of Agriculture. The staff consists of the Director (E. A. Griffiths), a plant physiologist, four technical assistants, a mechanic, and a typist. When complete, it will have, in addition, a bio-chemist and a mycologist.

In the building there are laboratories, offices, a library, and a workshop. There is also a series of eleven experimental cold chambers, each 8 feet x 9 feet x 6 feet, and each fitted with thermostats and long distance thermometers. Some of these are cooled by grids with circulating brine, and some with the battery system of circulating cold air. There are two ammonia compressors and one carbon dioxide compressor which can be used for cooling these chambers.

The cost of equipping the station was approximately £5,000, utilizing an old building, and the cost of maintenance with the present staff is approximately £5,000 a year, including salaries. It is proposed to erect a smaller experimental cold store in Pretoria, in the Botanical and Horticultural Laboratories, for any citrus problem which may require handling locally.

So far, the Low Temperature Research Laboratory has been mainly concerned with the application of existing knowledge to the question of transport. During the last few years the fruit export trade of South Africa has been entirely re-organized, and this has been largely the work of this department. The staff has also had to undertake administrative duties in connexion with the export of fruit. This re-organization is now almost completed, and the research staff is now able to devote time to laboratory research into problems of fruit storage.

As a result of the activities of this Research Department, the Government has built a large pre-cooling station at Cape Town, where all fruit is pre-cooled before export. This station, which was designed to the ideas of Mr. Griffiths, is a three-storied building situated on the quayside in the Table Bay docks. The lower floor can be used, in part, for ordinary merchandise, and the cool chambers, 72 in number, are situated on the first and second floors. Each chamber is fitted with long-distance thermometers which can be read from the engine-room. They are cooled by a sytem of ammonia batteries, which are arranged so that the cold air current may be concentrated, if required, on any chamber, or set of chambers, for rapid cooling. The air passing into the chamber is kept at the temperature to which the fruit is to be cooled, so that no freezing of the fruit is possible, quick cooling being brought about by the very rapid current of air through the chamber. It is possible to change the air in any chamber four times in a minute, and a chamber filled with fruit can be cooled in 12 to 24 hours.

The railway trucks carrying fruit are run into the store into an air-lock, which is cooled, and the fruit cases are unloaded, sorted, tallied, inspected, and put on to skids on wheels. These are wheeled on to an electric traverser, of which there are six, two on each floor, one on each side of the building, and are carried to a lift, in which they are transported to the upper floors. Traversers take them to the particular chamber required. After cooling they are wheeled out on the wharf side of the building, covered with a canopy to protect them from the air, carried by a traverser to the quayside hoists, and transferred, still on the skids, into the hold of the ship. The fruit is thus not handled from the time it is put on to the skids until it arrives in the hold. Each chamber is 47 feet by 15 feet, and will hold twelve skids each with 5 tons of fruit. The refrigeration is produced by two Hall ammonia compressors, each capable of 125 tons of refrigeration per day.

The cost of this pre-cooling station was approximately £250,000. It was erected by the Department of Railways and Harbours, but the administration, as of all the fruit export from South Africa, has been put temporarily in the hands of the Low Temperature Research Station. It is proposed to erect a smaller station at Durban at a cost of £160,000, designed for both fruit and meat.

Another piece of work of the Low Temperature Research Laboratory was the designing of a special form of refrigerator railway truck for carrying fruit over long distances. The journey from the Transvaal is

over 1,000 miles, and fruit may take as long as five days to arrive in Cape Town. During the summer very high temperatures may be experienced on the journey. These trucks are now in general use, and deciduous fruits are carried with great success. The trucks are fitted with overhead ice tanks, have double roofs, and the walls are insulated with powdered cork. A special form of door is used, 6 to 8 inches in thickness, and there is an arrangement for carrying off the condensation water so that the cases do not get wet. The trucks are charged with ice, about 3 tons, and allowed to stand for twenty-four hours before being loaded.

Experiments showed that with 3 tons of ice in the tanks, 30 tons of fruit, previously pre-cooled, could be carried in the summer months 1,000 miles with only a rise of 4 or 5 degrees in the temperature of the fruit, whilst after fourteen days, 10 per cent. of the ice was still left.

Recently successful experiments were carried out, in which fruit was brought from Calitzdorp, some distance from Cape Town, and where there is no means for pre-cooling, and the pre-cooling was done in the railway truck by filling the tanks with a mixture of ice and salt.

### 8. Work on the Conditions Obtaining in Ships' Holds.

By arrangement with the Union Castle Steamship Company, two experimental chambers have been fitted out on the *Windsor Castle* with distance thermometers, and $CO_2$ recording instruments, and on five voyages officers of the Research Laboratory have travelled to Great Britain with shipments of fruit, investigating conditions in the fruit chambers during the voyage. The results of these observations have been published in a special bulletin issued by the Department of Agriculture of South Africa.

# Soil Studies in Australia.

*Memorandum prepared for the purposes of the Imperial Agricultural Research Conference (1927) by Professor J. A. Prescott, Waite Agricultural Research Institute, Adelaide.*

The need for the study of the soil as a guide towards the progress of settlement in a new country, such as Australia, has been realized ever since the foundation of the early colonies, although this study has not necessarily been based on a scientific foundation. The early explorers all attempted to record, in some measure or other, the probable fertility of the soil, and their successors in closer settlement work, the surveyors of the Lands Departments, make soil classification part of their work. Such classification has been, however, of a very general nature, and areas have been classified into three or four classes; the first class of one district being possibly equal only to the second, or even third, class of another district.

Another crude system of classification in an area containing stony country or sandy formations has been to estimate roughly the proportion of land fit for arable cultivation. As a guide towards this classification, the surveyors and early settlers soon learnt that there was a close relationship between native vegetation and the possibilities of the land for agricultural purposes. The native flora was recognized as an index both of rainfall and of soil fertility, and in South Australia, for example, an early Surveyor-General, Goyder, was able to mark on the map the probable extent of agricultural development by noting the southern limit of salt bush and its associated flora. The need for improving methods of soil examination in the field has been recognized by the surveyors themselves, and, in South Australia, they were actually awaiting a lead from the Waite Institute, so that the survey of new areas is now being gradually improved, and the surveyors are learning to describe their soil types with scientific precision, and to note the native vegetation in greater detail.

Unlike soil survey work in other countries, in many parts of Australia information regarding soils has often been required ahead of topographical, or even detailed geological information, and the real soil surveyors have been the pioneer surveyors who mark out the boundaries of farms and parishes before settlement begins.

Research is needed to define more exactly the general characteristics of Australian soil types, and to find their place in some universally accepted system of soil classification, such as that derived from the systematic work of the Russian school of workers.

In the development of the irrigation areas of Australia, such as is at present in progress in the river Murray basin, and elsewhere, soil surveys and classification acquire a very fundamental importance. In the past, areas have been developed on soil classifications of the most simple character, and many mistakes have unfortunately been made. In some cases, the character of the native vegetation has been assumed to indicate suitability for profitable development for fruit-growing, and the assumption has proved to be incorrect. The problems in this connexion are particularly urgent, as important sums of moneys are involved, and it is in the interests of all concerned that such mistakes should be avoided in the future.

The problems of classification and of soil fertility in the irrigation areas may be grouped as follow:—

(i) The study of the physical and chemical properties of the soil in relation to the suitability for various crops, such as vines, citrus fruit, rice, market garden crops, and lucerne.

(ii) The study of the problems of soil fertility associated with soil acidity, alkalinity and salinity, and the general poverty in plant foods, particularly nitrogen and phosphoric acid.

(iii) The study of the conditions, partly topographical, partly hydraulic, conducive to seepage.

A close study of such problems in the field and in the laboratory should give results of value to those interested in the devlopment of new areas, and would also be of importance to those engaged in advisory and instructional services to settlers.

The Council for Scientific and Industrial Research is supporting investigational work along the above lines, to be carried out at the Waite Agricultural Research Institute, and it is hoped that this work will be carried out in close co-operation with the organizations interested in development, and in investigation in those areas, such as the Citrus Research Station at Griffith, and the State Departments of Agriculture, and of Irrigation.

In Queensland, there has recently been constituted an organization which is engaged on a survey of the natural resources in soils and vegetation, as a guide towards the development of agriculture in the more tropical areas of that State.

Soil investigation, particularly on the chemical side, has been carried out for many years by the chemists of the various State Departments, but the burden of advisory and routine work has, in many cases, precluded the development of systematic work. Of necessity, much of this advisory work has had to seek for its standards elsewhere. Problems have had to be investigated purely from a local point of view, and many have had to be shelved until more information of a fundamental character was made available.

The need for this information on all branches of soil science is very urgent, and it is hoped that the immediate future will see the development of such soil research as will enable the developmental, advisory, and extension services to become increasingly effective.

# The Japanese Institute of Physical and Chemical Research.

During the Pan Pacific Science Congress, held in Japan recently, delegates were given a pamphlet entitled, " Guide to the Institute of Physical and Chemical Research," Tokyo, 1926. The following account is based on the information given in that pamphlet. It should be noted that the Institute practically confines its attentions to problems concerning Japanese manufacturing and secondary industries.—Ed.

*Endowment and Establishment.*—The Japanese Institute of Physical and Chemical Research, founded on the 20th March, 1917, is a corporation endowed with a total fund of 6,228,700 yen (£623,000), of which 1,000,000 yen (£100,000) was an Imperial gift, 2,000,000 yen (£200,000) a Government subsidy, and 3,228,700 yen (£322,000) contributions from official sources as well as from individuals. The Institute occupies a site covering 12,000 tsubo (almost 10 acres), which is situated in the two wards of Hongo and Koishikawa, in the City of Tokyo.

*Purposes.*—The Institute conducts investigations in the pure sciences of physics and chemistry, aiming at their industrial development, and at the same time engaging in applied research. No undertaking, whether it be in industry or agriculture, would be able to attain sound development unless it were based upon physics and chemistry. Particularly in such a densely populated country as Japan, where industrial materials as well as other commodities are not ample, it is essential to aim at the development of industry by having recourse to science, thereby promoting national interest. The object of the Institute is to perform this important mission.

*Industrial Experiments.*—When any physico-chemical applied research is completed in the laboratory, it is tested for its industrial applicability, and in case the test shows an appropriate result, arrangement for manufacture is carried out at the Institute, and the work is commenced, or the manufacturing is entrusted to others, or a new company may be established on the basis of a remunerative contract with the Institute, depending upon the nature of the work. As the fundamental cause of success in these applied researches lies in there being sound scientific investigations at the back of them, a part of any profit accruing to the Institute is allotted to the investigation expense of pure science, and a further part is given as a reward to the inventor or discoverer.

*Manufacture of Instruments.*—Delicate instruments to be used in physico-chemical research are of special construction, and cannot be manufactured in ordinary factories. The Institute is equipped with instrument manufacturing quarters on a comparatively large scale, and besides manufacturing and repairing the instruments to be used in the Institute, some special implements and instruments for investigational purposes are manufactured on orders from outside. Those at present manufactured in the Institute are still small in number; but delicate instruments, surveying instruments, and the like previously imported from abroad, are not only being manufactured with success, but some are even superior to foreign products.

*Laboratories.*—Laboratories, of which there are at present 24, are known by the names of the Chief Investigators. They are not necessarily located in the Institute, some of them being situated where the Chief Investigators are placed. For instance, whole or part of the Ishi-

kawa, Honda, and Majima (Ri)laboratories are located in the Tohoku Imperial University, with permission of the president of that University; the Katayama Laboratory, in the Tokyo Imperial University, in the same manner as above; and the Kita and Kimura Laboratories in the Kyoto Imperial University.

Each laboratory has its own budget, and the defrayment of the expenses is left to the Chief Investigator. Each of the latter has a free hand in deciding on the ratio of the disbursal of funds between laboratory equipment and salaries in his own laboratory.

*Problems Under Investigation.*—The lines of research pursued last year covered 154 distinct investigations, while they have increased this year to 171. The Chief Investigators are perfectly free in their choice of research problems, no limitation being put on the sphere of the investigations. For example, a chemist may engage in research in physics, or *vice versa.* For the result of the work, however, the investigators are absolutely responsible.

*Publication of Results.*—The investigations completed in the Institute are published in the Scientific Papers of the Institute of Physical and Chemical Research (in European languages), or in the report of the Institute of Physical and Chemical Research. The report from Vols. 1-5, 25 numbers, and the Scientific Papers (in European languages), from Vols. 1-5, 76 issues, have already been printed, and are sold to the public extensively. In some cases the results of investigations are inserted in the appropriate domestic and foreign magazines. They are also made public at lectures held for the purpose.

*Buildings and Equipment.*—The buildings and equipment of the Institute were commenced in 1918, and finally completed in 1925. Together with the progress in the investigations, however, it became necessary to enlarge the equipment, or to install new apparatus for semi-industrial experiments. Consequently such buildings and equipment were added, and the construction expense since the time of establishment until the end of the fiscal year for 1925, reached 4,071,000 yen (£407,000) in all, including the cost of the ground.

*Patent Rights.*—The domestic and foreign patent rights possessed by the Institute up to May, 1926, covered 103 items (domestic), 21 items (foreign), 4 items (utility model), and 7 items (registered trade mark).

*Ordinary Expenditure.*—The expenditure of the Institute is disbursed from the interest accruing from the fund, from an annual Government subsidy of 250,000 yen (£25,000), from profit arising from the industries that have come into existence as results of researches, and the like. For the year 1926, it was expected that the total expenditure of the Institute would be 891,456 yen (£89,000), made up of the above Government subsidy, of interest from the fund of 127,000 yen (£12,700), and of revenue from factories, royalties, &c., 514,456 yen (£51,400).

*Members, Officials, and Staff (on the basis of June,* 1926).—Members of the corporation number 177. Officials consist of 1 president, 3 advisers, 14 directors, 6 managers, and a consultation committee of 74. Staff members number 384, divided into the following groups:—Directly engaged in the investigations, 216 (chief investigators 24, investigators 9, assistants 47, associates 28, research students 80, employees 28); technical experts and subordinates assisting in investigations, 83; apprentices being trained in factories, 16; technical experts and subordinates engaged in experimental factory work, 41; office clerks and subordinates, 6; and miscellaneous employees and subordinates, 22.

# "Contagious Bovine Pleuro-Pneumonia: Its Diagnosis by Means of Serological Tests.

*By T. S. Gregory, B.V.Sc. (Melb.).*

Mr. Gregory is one of the investigators appointed by the Council to study certain animal problems. He has been accommodated at the Veterinary Research Institute, University of Melbourne, by the kindness of Professor H. A. Woodruff, the Director of the Institute. The work reported below has also been carried out under the direction of Professor Woodruff.—Ed.



## 1. General.

For many years the diagnosis of this disease has depended entirely upon clinical signs and symptoms shown by affected animals. Thus, in a newly infected herd attention might first be drawn to the presence of a slight cough in one or more animals, and then later on, to the development of general unthriftiness and dyspnoea, followed by death. The occurrence of such symptoms would generally stimulate the careful owner to consult a veterinary practitioner or State Departmental officer, and a post-mortem examination of an affected beast would confirm the suspicions of contagious pleuro-pneumonia. This having been done, such a herd in most organized States would immediately be subjected to the existing veterinary police measures. These measures vary in different countries according to the incidence of the disease. Where the occurrence is rare, the policy usually adopted is that of slaughtering the whole herd together with all possible contacts. This is followed by enforcement of strict quarantine measures in the affected area, for a long period.

If on the other hand the disease is of frequent occurrence, such steps are too drastic and undesirable from an economic point of view, so that only animals which show symptoms of the disease are slaughtered, whilst the remainder are presumed to be unaffected and are protectively inoculated. They are then left in quarantine for a period of about twelve weeks after the occurrence of the last case.

In order to detect any infected animals in a suspected area, temperatures are taken as frequently as possible, any marked rise being taken as an indication of the onset of the disease. Other methods of clinical examination, such as auscultation and percussion, are carried out as far as possible, but they are difficult to execute carefully under field conditions and in the time available. Moreover, it is extremely difficult to detect infected animals with any certainty by these latter means, as the lesions may be small and deep-seated in the lung.

Generally speaking, where control by clinical signs is being attempted, the animals showing obvious symptoms are slaughtered, and those showing a rise of temperature are isolated for further observation. Some of these isolated animals later on develop more marked symptoms and are in turn slaughtered, whilst others are released at the end of the quarantine period, if their temperature returns to normal and if they are in no other way suspicious.

These are the methods which obtained universally until a comparatively few years ago, and they are largely practised at the present time. Of the two policies that of slaughter of all infected and all in-contact cattle has alone been successful. The policy of slaughtering only animals detected by clinical means as being affected with the disease, generally fails to eradicate the infection, and can only be described as a more or less unsatisfactory means of control, and one which involves a serious amount of trouble and expense to the owner and a minimum of satisfaction to the veterinary officer in charge. The main reason for the failure of this policy is bound up with the nature of the disease. Firstly, there is the occurrence of a number of cases in which infection takes place without giving rise to any well-marked clinical symptoms; and secondly there are those cases in which, after a mild and probably undetected attack, the affected piece of lung becomes encapsuled by fibrous tissue and then undergoes further retrogressive changes. Such encapsuled foci may appear completely isolated, but sooner or later during degenerative processes some of the infective material, which even after several months is still virulent, escapes into the surrounding healthy tissues and starts a new focus of infection. The disease having taken on a new lease of life may then extend greatly, leading to death of the animal, or it may again be checked; but in this "open" stage of the lesion the animal is capable of infecting other cattle. These carriers of chronic lesions—often referred to as "lungers"—very frequently escape detection by clinical examination, especially under field conditions. If the temperature of all cattle on an affected farm were taken daily, which is not always possible, they might only show a slight rise on one or two occasions, and this might frequently be passed over entirely, or if noted, might be considered as due to handling, or to some passing digestive disturbance. One or more of these carriers of chronic lesions thus escaping observation might ultimately be released from quarantine, and after a period of quiescence possibly of many months' duration, might become "open" and cause another outbreak in the original herd, or sometimes in other widely separated herds if members of the originally infected herd had been sold in the meantime.

In a country like Australia in which the disease has existed for many years, the percentage of animals which do not show acute symptoms but which become carriers, appears to have increased, and the spread of the disease has become more insidious.

It is for the foregoing reasons that the discovery of other and better means of diagnosis becomes important, and efforts were made to find a reliable serological test.

In the Melbourne University Veterinary Research Institute, work on this subject was commenced by G. G. Heslop in 1920. In his first work, Heslop found that "agglutinins could not be demonstrated in the serum of animals known to be affected with contagious bovine pleuropneumonia" (1). However, he was able to demonstrate the fact that "complement fixing antibodies are present in the serum of animals affected with the disease, and a complement fixation test can be used to differentiate infected from non-infected animals" (1). During his later work he came to the conclusion that "the technique of this test is too intricate and laborious to allow of its adoption as a routine diagnostic method." (2). However, as a result of his latest researches Heslop was able to demonstrate specific agglutinins in the serum of animals affected with contagious pleuro-pneumonia, and he

described a technique for agglutination test which he considered "provided a simple means for determining the presence of the disease, at least in the acute form, in the living animal." Unfortunately another complication arose when in further carrying out this test he discovered the presence of at least two distinct types of the contagious pleuro-pneumonia virus which he called types X and Y. With regard to the effect of this complication he reported that "wherever a known positive is unobtainable from the outbreak in which suspected animals are, it becomes necessary to test each suspected serum twice—firstly, against type X, and secondly, against type Y, each separately—before it can definitely be stated that the animal supplying the sample is affected with, or is free from the disease." This complication therefore rendered the test more difficult. Heslop also remarked that "the agglutination reaction in contagious pleuro-pneumonia is always more marked and definite with the serum of an animal in which the disease is acute than that from an animal in which the disease is chronic." (3).

In 1926, work was undertaken by A. W. Turner, especially with regard to complement fixation. As a result of researches by Tietze and Giese (4), many of the earlier difficulties had been overcome, and the technique of these authors was largely followed. Turner (5) obtained generally excellent results, though at times he found a percentage of positive reactions unconfirmed on post-mortem examination. These erroneous results he suspected to be due to the presence of complement fixing antibodies subsequent to and resulting from protective inoculation of these animals. At the time, the opportunity was lacking to test this hypothesis, and Turner concluded his report by saying "we regard the test as reasonably accurate; but future work should be strictly limited to blood samples taken from animals before any protective inoculation has been practised on them."

It was at this stage that the writer, then newly appointed a research worker by the Council for Scientific and Industrial Research, commenced work on this subject. It was decided first of all to determine the effect upon the test of previous inoculation. Samples of blood were obtained from animals which had been noted by State Departmental veterinary officers in the field as "bad reactors," i.e., those in which the reaction to an inoculation with "virus" had extended beyond the ordinary limits, up the tail or to the rump, with subsequent sloughing of the tail. It was found that samples of blood from these animals gave, without exception, a very definite positive result, i.e., definite fixation of complement in the presence of specific contagious pleuro-pneumonia antigen. Experimental animals used in immunity tests also gave positive results after inoculation with natural virus.

It was therefore evident that inoculated animals would give definite positive results in the absence of the disease, and therefore that positive results of blood samples would be of diagnostic value only if obtained from un-inoculated herds.

Since arriving at this important conclusion approximately 500 animals have been tested, and the results are tabulated below. Not all of these animals can be accurately reported upon, as the majority of negative reactors have not been further dealt with. The results include animals from both inoculated and un-inoculated herds, but they are divided accordingly.

## 2. Results in Uninoculated Herds.

*(A) Post-Mortem Findings in "Positive" Reactors to Complement Fixation Test.*

| Total. | Contagious pleuro-pneumonia confirmed. | No discoverable lesions of contagious pleuro-pneumonia. | Correctly diagnosed. |
|---|---|---|---|
| 74 | 47 | 27 | 63.5% |

Included among these are a number of animals, the serum of which gave only slight fixation of complement. These animals should really have been classified as "suspicious" or "doubtful." However, as it was often impracticable to forward fresh samples for a re-test at a later date, these "doubtful" reactors were placed amongst the "positives" in order to ensure that no infective animals should be left in the herds. A number of these doubtful reactors killed out clean, and so the percentage of accuracy was greatly reduced.

Among the 27 positive reactors in which, on post-mortem examination, no lesions of pleuro-pneumonia were discoverable, are a number in which the error was traceable to the use of carbolic acid in the antigen used during those tests. The carbolic acid was added to the antigen as a preservative, but it was later found that such antigen developed anti-complementary properties, which gave rise to false reactions. It must, therefore, be borne in mind that this percentage of accuracy was obtained under various experimental conditions and should be materially increased by the use of proved standardized methods.

*(B) Post-Mortem Findings in Negative Reactors to the Complement Fixation Test.*

| Total. | No discoverable contagious pleuro-pneumonia lesions. | Contagious pleuro-pneumonia confirmed. | Correctly diagnosed. |
|---|---|---|---|
| 34 | 28 | 6 | 82.3% |

In considering these last results, it should be remembered that slaughter was not always carried out immediately after the blood sample had been taken, and that these negative reactors were in contact with infected animals in many cases, and so were liable to become infected during the interval. Thus, of the above six infected cattle, the time between the taking of the blood sample and slaughter was three weeks in the case of three, two weeks in the case of two, and one week in that of one. In practically all these cases, the lesions were recent and active, and probably started after the blood was taken.

The real accuracy of the test for negative reactors is therefore probably above 90 per cent.; in other words, a negative reaction may be relied upon to indicate freedom from the disease.

## 3. Results in Inoculated Herds.

The animals in this group were in herds in which contagious pleuro-pneumonia had definitely been diagnosed by a Departmental Veterinary Officer, and where the in-contact animals had been inoculated in the usual manner with either natural virus (i.e., lung exudate) or pure

culture. The results of the tests and of post-mortem findings are as follows:—

(*A*) *Post-Mortem Findings in Positive Reactors to Complement Fixation Test.*

| Total. | Contagious pleuro-pneumonia confirmed. | No lesions of contagious pleuro-pneumonia discoverable. | Correctly diagnosed. |
|---|---|---|---|
| 45 | 21 | 24 | 46.6% |

These figures confirm the statements previously set out. The lower percentage of agreement between reactions and post-mortem findings is due to the presence of contagious pleuro-pneumonia antibodies, produced as a result of protective inoculation and not as a result of the presence of lesions of the disease.

(*B*) *Post-Mortem Findings in Negative Reactors to Complement Fixation Test.*

| Total. | Contagious pleuro-pneumonia confirmed. | No lesions of contagious pleuro-pneumonia discoverable. | Correctly diagnosed. |
|---|---|---|---|
| 25 | 4 | 21 | 84% |

Here again, as in the case of the negative reactors from uninoculated herds, there was, in many cases, an interval of a week or more between bleeding and slaughter, with the consequent possibility of infection, or at any rate of the production of antibodies during this time in some at least of the four animals showing lesions. Had a sample of blood been obtained at the time of slaughter, it is probable that the correlation between the test results and post-mortem findings would have been better. As a negative reaction indicates the complete absence of contagious pleuro-pneumonia complement fixing antibodies, such a result would bear the same interpretation whether from a herd previously inoculated or uninoculated. The figures from the two types of herds are seen to be in close agreement and show a similar degree of reliability.

### 4. General Consideration of Results.

Generally speaking, the positive results have proved quite satisfactory in uninoculated herds. The percentage of the correctly diagnosed cases justifies the test, especially when one considers the number of chronic lesions which are revealed, i.e., lesions the presence of which, apart from the test, could not be diagnosed. Among these positive reactors have been found lesions from the size of a marble upwards, in various stages of encapsulation and necrosis. These animals would not have given the slightest clinical symptom, nor would any rise of temperature have been expected to be detected under field conditions of examination.

Negative reactors have proved very satisfactory in both inoculated and uninoculated herds. There should be no difference in these, and the results were indeed very similar with almost the same percentage of reliability. The high efficiency of the test in regard to negative reactors is extremely important, for if all positively reacting animals were removed from the herd, it is almost certain that the remainder—i.e., the negative reactors—would be clean. As an extra precaution, a re-test could and should be undertaken in fourteen days' time, in order to make sure that no animals which were in an early incubation stage, not yet having produced complement fixing antibodies, were passed over.

An examination of the results of the test on some individual herds proves of interest. For instance, seventeen animals from one farm were tested and slaughtered ten days later. Of these, six animals were

negative to the test and were free from contagious pleuro-pneumonia on post-mortem. Nine gave strong positive reactions and all but one were infected with contagious pleuro-pneumonia. Two gave weak positive reactions (i.e., partial fixation), and these showed small areas of early pneumonia which could not be definitely stated as contagious pleuro-pneumonia or otherwise. It is obvious that in this herd, if the positive reactors had been removed, the disease would have been eradicated. If, on the other hand, no blood test had been applied, it may safely be said that the majority of the eight infected animals could not have been detected by clinical examination.

The results of tests on inoculated herds vary greatly in accuracy and give rise to some problems. In a herd which had been inoculated and which was slaughtered soon after the test, all the negative reactors were free from contagious pleuro-pneumonia, but of the positive reactors only one out of ten had contagious pleuro-pneumonia lesions. This means that they reacted positively owing to the stimulation of the formation of complement fixing bodies by protective inoculation. On the other hand, a herd which had been protectively inoculated in November and which was tested in April, proved to have among the positive reactors 75 per cent. (six out of eight) affected with contagious pleuro-pneumonia. Of 21 negative reactors, nineteen were clean and two were affected. Evidently in this case, antibodies had either not been formed after protective inoculation, or else they had disappeared during the ensuing five months. In a case such as this questions arise as to the degree of immunity provided by inoculation, whether it varies as does the production of complement fixing bodies with the particular virus used, and what is its duration.

### 5. Technique of Test.

In the actual practice of the test, it is to be expected that eventually haemolysis will occur in the majority of the tubes, even in those containing positive sera, in which definite fixation of complement has occurred. This action is probably due to conglutinins which are markedly present in the serum of bovines; these bodies, in the presence of a very small amount of free complement, first agglutinate the sensitized red cells, then cause haemolysis. This haemolysis by conglutinins even in positive tubes confuses the reading of results, but the method evolved by Tietze and Giese adequately overcomes this difficulty.

The antigens used by the writer have been prepared from cultures of the virus of contagious pleuro-pneumonia in a glucose, ox-flesh broth with the addition of 10 per cent. horse serum. The preparation of this medium was described in the original papers of Tietze and Giese. It has been found that such cultures proved best for antigenic purposes if allowed to grow for six to eight weeks. After preparation by heating at 60 deg. C. for two hours, they are preserved for use in sterile sealed ampoules. During some earlier experiments this procedure was departed from, and preservation ensured by the addition of 0.5 per cent. carbolic acid. It was found, however, that this addition led to the development of anti-complementary properties in the antigen and consequently to a number of false positive reactions.

The preliminary determination of units of the factors used in the test takes place in the ordinary way, and whereas the unit of antigen has been found generally to be between 0.5 c.cs. to 1.0 c.cs., the anti-complementary dose of this antigen was rarely less than four times

these amounts. The unit of red cells used has been 0.5 c.cs. of a 3 per cent. suspension. Amounts of 0.1 c.c. to 0.2 c.cs. of the serum to be tested have been used, without any apparent difference in the reactions. Control tubes to which antigen is not added have been used for each serum in the final test in order to reveal any anti-complementary properties, but 0.2 c.cs. of serum—the amount generally used—has rarely proved anti-complementary.

The most important titration is that for the determination of the amount of complement to be used. This is carried out simultaneously in two series of tubes. Each series contains the determined amount of antigen and gradually increasing amounts of 10 per cent. complement from 0.2 up to 0.75 c.cs. To the first series is added the determined amount (0.2 c.cs. has generally been used) of a known positive serum, and to the second series a similar amount of a known negative serum. All the tubes are then brought up to an equal volume with normal saline solution and placed in the water bath for fifteen minutes at 38 deg. C. One unit of red cells, and two and one-half units of haemolytic amboceptor, are then added. The progress of haemolysis is carefully watched with a view to noting the difference in time of its occurrence between corresponding positive and negative sera. With complete haemolysis proceeding quickly down the row of negative sera, the corresponding tubes of positive sera are observed, and when the greatest difference in this progress of haemolysis in the two rows is apparent, the pair of tubes in which, with complete fixation in the one and complete haemolysis in the other, there is the least amount of complement, is recorded. The time factor is of importance. If the tubes are left too long before examination all of them, both negative and positive, will show haemolysis. The maximum distinction between the two rows will be seen in from eight to fifteen minutes.

Thus two rows of tubes, one containing a positive serum and the other a negative serum, are set up as follows:—

*Serum*—

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

*Antigen* (units)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

*Complement* (c.c.)—

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 |

*Saline—Ad* 3 c.c. in each tube.

Incubate at 38°C.

Add 1 unit of red cells and 2½ units of haemolytic amboceptor to all tubes in both rows, and incubate.

*Reading after* 10 *minutes*—

*Positive Serum*—

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | + | + | + | ++ | ++ |

*Negative Serum*—

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| + | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |

— Denotes complete fixation. +++ Denotes complete haemolysis.

Unit of complement=0.3 c.c.

Thus, in the principal test, 0.2 c.cs. of the suspect sera would be warmed at 38° for 15 minutes in the presence of the unit of antigen and 0.3 c.cs of complement. The unit of red cells and 2½ units of

haemolytic amboceptor would then be added, and the test read after 10 minutes, provided that the control known positive sera show complete fixation and the known negative sera are completely haemolysed.

*Table Showing the Procedure in the Final Test.*

*1st row*—

| | |
|---|---|
| Suspect sera (of each) .. .. .. | 0.2 c.c. |
| 10% complement .. .. .. | Titrated unit. |
| Contagious pleuro-pneumonia antigen .. | Determined amount. |
| Saline .. .. .. .. | *Ad* 3 c.c. |

Incubate 15 minutes at 38°C.

Add 1 unit of red cells sensitized with 2½ units of haemolytic amboceptor.

*2nd row*—

The same except that contagious pleuro-pneumonia antigen is replaced by an equal amount of normal saline solution. This serves as a control for the anti-complementary properties of each serum.

Read the test after the time previously determined. Haemolysis should then be complete in all the tubes of the second row unless some individual sera are showing marked anti-complementary properties. These latter tubes should be specially noted. In the first row, control tubes containing known negative sera should show complete haemolysis, and those containing known positive sera complete fixation. Results of the test of the suspect sera in the first row are registered as positive in tubes showing complete fixation, negative in those showing complete haemolysis, and suspicious where there is incomplete haemolysis.

In more recent tests it has been found advisable to modify the technique by increasing the time allowed for fixation of the complement before the addition of red cells and amboceptor. Further, if the red cells are sensitized by admixture with inactivated haemolytic amboceptor for 1 hour before addition, the results of the test are more sharply defined and capable of being more easily interpreted.

Up till the present time a large number of sera from various districts in Victoria have been tested against antigens prepared from cultures of the virus obtained from widely separated outbreaks, and no complications have arisen owing to difference in type or strain of the pleuro-pneumonia virus.

## 6. Summary.

From the result of these experiments the complement fixation test for diagnosis of pleuro-pneumonia has been proved worthy of use under field conditions. It is of great help in picking out carriers of chronic lesions which cannot be detected clinically, and great reliance may be placed on the verdict of freedom from contagious pleuro-pneumonia in the case of negative reactors. It should, therefore, be of use for testing animals before allowing them to pass from an infected locality to a clean herd or State.

It is essential that the animals should not have been protectively inoculated before the test, and a second test of negative reactors after an interval would eliminate the chances of passing over animals which were in an early incubation stage, and therefore not producing antibodies at the time of the first bleeding.

### 7. Acknowledgment.

The writer desires to thank the Chief Veterinary Officer of the Victorian Department of Agriculture, Mr. E. A. Kendall, B.V.Sc., and his staff, for their co-operation in forwarding suitable samples of sera for examination, and in furnishing the results of post-mortem examinations.

### 8. References.

No. 1. Heslop (1921) *Proc. Royal Soc. Victoria* (n.s.), Vol. XXXIII.

No. 2. Heslop (1922) *Jour. Compar. Path. & Ther.*, Pt. 1, 1922.

No. 3. Heslop (1923) *Proc. Royal Soc. Victoria,* Vol. XXXVI. (n.s.), Pt. 11.

No. 4. *Arbeiten ausdem Reichsgesundheitsamte,* Vol. 53, Pt. 4 (1923).

No. 5. Report unpublished.

# NOTES.

### Research on Animal Diseases at the Adelaide Hospital.

One of the recommendations made by the Conference of Veterinary Pathologists referred to in the previous issue of the *Journal* (page 19) was that investigations of (*a*) haematuria in cattle; (*b*) toxaemic condition in lambs; and (*c*) ante-parturient paralysis in ewes should be undertaken. It was further recommended by the Conference (i) that this work should be carried out under the direction of Dr. Lionel Bull, Director of the Government Laboratory of Bacteriology and Pathology, located at the Adelaide Hospital; and (ii) that Dr. Bull should be provided with the services of a suitably trained investigator.

For some time it was found to be impracticable to give effect to the recommendation, as the necessary investigator was not available. The Council has now obtained the services of Mr. Campbell G. Dickinson, B.V.Sc., a graduate of the Melbourne University. Mr. Dickinson commenced his investigations at Adelaide on the 8th of August last.

## PLATE 1.

# SPOTTED WILT OF TOMATOES.


FIG. 1.—Thrips Transmission Experiment No. 1. Two controls, and two infected plants nine weeks after thrips had been placed on them. Variety of plants—Golden Queen (26th August, 1927).


FIG. 2.—Thrips Transmission Experiment No. 2. Two controls, and two infected plants five weeks after thrips had been placed on them. Variety of plants—Burwood Prize (26th August, 1927).

C.14623.

PLATE 2.

# THE EXPORT OF FRUIT FROM SOUTH AFRICA.

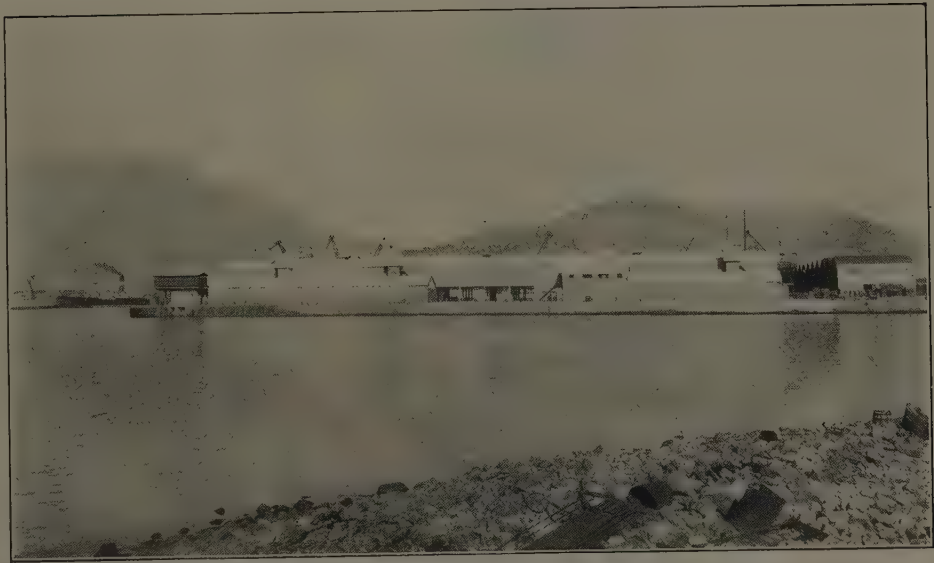

FIG. 1.—The Pre-cooling Station at Cape Town.
(Side view showing the Docks and Table Mountain in the rear.)
*(Photograph furnished by the authorities of the Station.)*

PLATE 3.

# THE EXPORT OF FRUIT FROM SOUTH AFRICA.

Fig. 2.—The Pre-cooling Station, Cape Town. (End view.)

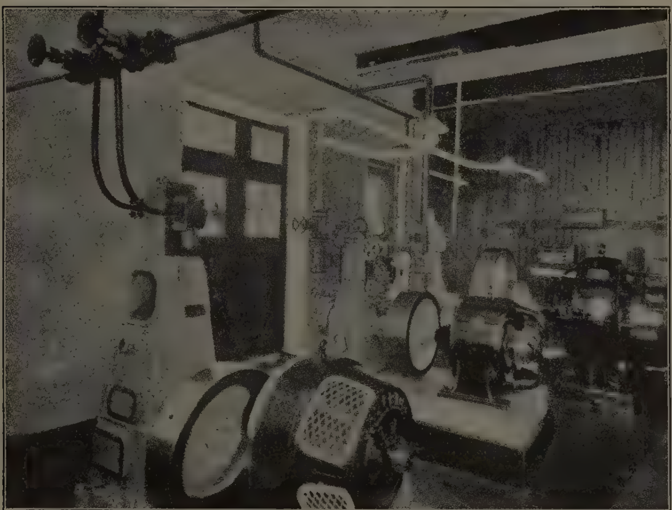

Fig. 3.—The Engine Room of the Low Temperature Research Laboratory, Cape Town. Three compressors and (on the rear wall) electric recorders which register the temperatures in each of the chambers.

(*Photographs furnished by the authorities of the Station.*)

PLATE 4.

THE COMMONWEALTH RESEARCH STATION, MURRUMBIDGEE IRRIGATION AREAS.

FIG. 1.—Restricted root development of an orange tree resultant on a high water table.

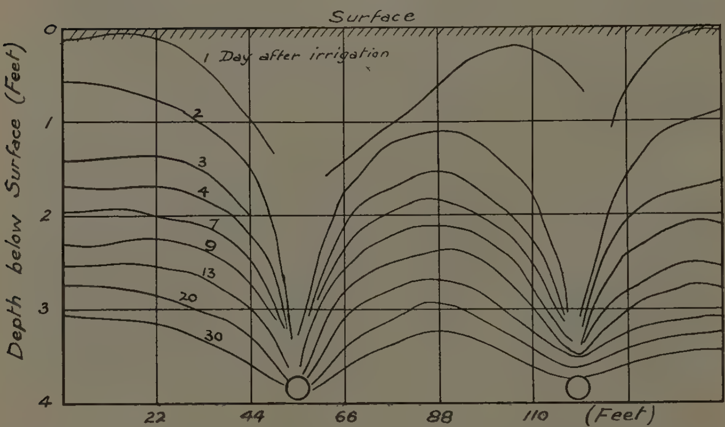


FIG. 2.—Illustrating the effect of tile drains on the water table. The figure represents a vertical section, the circles indicating the positions of the drains, and the curves the positions of the water table at a number of different days after irrigation.

## NOTES—*continued.*

### The Empire Marketing Board.

At the meeting of the Imperial Economic Conference, held on the 6th November, 1923, it was considered desirable to establish an Imperial Economic Committee composed of representatives of the Governments represented at that Conference, and with the function of advising on certain matters of an economic and commercial character. Some time later this Committee was set up with the following terms of reference:—

"To consider the possibility of improving the methods of preparing for market, and marketing within the United Kingdom, the food products of the overseas parts of the Empire, with a view to increasing the consumption of such products in the United Kingdom in preference to imports from foreign countries, and to promote the interests both of producers and consumers."

As supplementary to the above terms of reference, the Committee was asked to suggest schemes upon which a sum of £1,000,000 per annum might usefully be spent. The British Government had proposed to set aside this amount for the Committee's purposes.

Shortly after its formation, the Committee recommended, *inter alia,* as follows:—

"(i) That a Commission, which we speak of provisionally as the Executive Commission, should be formed on the model of the existing Development and Forestry Commissions for the purpose of supervising the expenditure of the annual grant from the British Parliament.

(ii) That this Commission should be charged with the duty of conducting the movement for trade in Empire produce.

(iii) That we regard a scheme for co-ordinated research into the production and preservation of foodstuffs as of prime importance.

(iv) That the Executive Commission should start by allocating about 65 per cent. of the annual grant for the promotion of trade in Empire produce, and about 15 per cent. for research.

(v) That this remaining 20 per cent. should be reserved for certain other schemes, of which we have mentioned two, namely, the promotion of fruit-growing in the tropical portions of the Empire, and the carriage of pedigree stock from the United Kingdom to the Overseas parts of the Empire."

The Executive Committee referred to above was created in May, 1926, under the name of the *Empire Marketing Board.* The Chairman of the Board is the Secretary of State for Dominion Affairs and for the Colonies (the Right Hon. L. S. Amery, M.P.). The representative of Australia on the Board is Mr. F. L. McDougall, C.M.G.

It will be seen that the Board is charged with the duty of conducting the movement for trade in Empire produce, and that its functions fall into the three divisions of (*a*) publicity and education; (*b*) research; and (*c*) the promotion of schemes for the improvement of production and marketing.

That the Board is destined to exercise a very important and beneficial influence on the production of agricultural produce within the Empire seems to be indisputable. It has already been a potent factor

in the initiation of important researches, and in that connexion has adopted the policy of disbursing its funds through existing channels, and in the subsidizing of existing institutions rather than by creating new laboratories. Through its Research Grants Committee, it has already agreed to disburse a considerable amount of funds. It has, for instance, arranged for the subsidy of a chain of tropical and semi-tropical agricultural research stations, grants having been made to the Imperial College of Tropical Agriculture, Trinidad; to the Amani Institute, Tanganyika; and the preliminary steps are being taken prior to the subsidy of a station proposed to be established in Northern Australia. The Board is subsidizing the work on the cold storage and transport of foods being undertaken by the British Food Investigation Board. It is helping the Imperial Bureau of Entomology, chiefly in the direction of the establishment of the parasite laboratory or "Zoo" of beneficial insects referred to elsewhere in these "Notes." It is subsidizing work of a similar nature being undertaken at the Cawthron Institute, New Zealand, and contributing towards the cost of fundamental work on the nutrition of stock being carried out at the Rowett Institute, Scotland, in Kenya Colony, at the Waite Institute, Adelaide, and in New Zealand. In addition, the Board is subsidizing researches being carried out in various parts of the Empire on animal breeding, economic botany, fruit-growing, dairying, and on poultry production.

As has been previously indicated, the subsidy of research is but one of the functions of the Board, and it has already made extensive contributions in other directions, all aimed, however, at the greater economic development of the Empire's primary industries.

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## Questionnaires from Empire Marketing Board.

As part of its general research policy, the Empire Marketing Board has recently prepared several pamphlets, comprising memoranda and questionnaires on special subjects. Each individual memorandum consists of a short statement of the problem, and each questionnaire contains several questions designed to obtain precise information as to what those in receipt of the questionnaire are doing in regard to the problem. In this way the Board will obtain full information as to the activities of the various research organizations of the Empire in certain directions, and this knowledge will undoubtedly be of considerable help to it in the carrying out of its special functions.

Four memoranda and questionnaires have already been received in Australia. These relate to (*a*) the standardization of horticultural material by selection and vegetative propagation, with special reference to rootstock influence; (*b*) irrigation practice on problems in the Empire; (*c*) the dissemination of the results of scientific research among primary producers; and (*d*) the determination of the effect on fruit quality of nutritional conditions, and its relation to marketing problems.

The pamphlet on the standardization of horticultural material was prepared by Mr. R. G. Hatton, M.A., Director of the East Malling Fruit Research Station (England), following on a conference of scientific workers interested in the subject. The following extract is taken from the preface to the pamphlet:—"The problem of standardizing horticultural material, and of securing uniform root-stocks affects many other fruits than those to which the work at East Malling has been

applied; and the present paper is circulated in the hope that it may afford a short summary, useful to those who have similar problems to meet, and that it may elicit from scientific workers in different parts of the Empire information which will enlarge the common stock of Empire knowledge on the subject."

The pamphlet on irrigation was written by Dr. B. A. Keen, who is the Assistant Director of the Rothamsted Experimental Station, which has for many years been the main centre in Great Britain for the study of soil problems. It is of particular interest from the point of view of the effects of irrigation on soils, if practised over many years.

The pamphlet on the dissemination of the results of scientific research is of special interest to those whose function it is to bring about a widespread introduction of new and better farming practice. The pamphlet on the determination of the quality of fruit was prepared by Professor B. T. P. Barker, Director of the Long Ashton Horticultural Research Station (Great Britain). It is of particular interest to those concerned with the cold storage of fruit. It discusses the new investigations that are to be initiated in Great Britain in an attempt to discover the fundamental reasons for the storage lives of specimens of the same variety of fruit differing so greatly despite the fact that the specimens may have come from neighbouring trees of the same orchard. A summary appearing in the pamphlet is as follows:—

"(*a*) The value of the fruit crop to the grower is closely correlated with its condition in respect of soundness and appearance when it reaches the retail market.

(*b*) Such condition, while to some extent controllable by methods of handling and storage, is ultimately dependent on the inherent characters of the fruit itself, which may be covered by the general term 'quality.'

(*c*) Quality is determined by a combination of factors affecting the growth of the tree, some controllable, others uncontrollable.

(*d*) Existing knowledge of the effects of these factors, individually and in combination, on fruit quality, is very limited, but, so far as it goes, indicates that it should be possible for the grower to exercise a considerable degree of control on quality, given further knowledge.

(*e*) It should be possible to elucidate principles of general application to fruit culture in any country, subject to the necessary adaptation to local conditions."

## Geophysical Prospecting.

It can fairly be claimed for the methods of prospecting by geophysical means that they are among the most important developments that have taken place in connexion with the mining industry of recent years. In particular, the electrical, the magnetic, and the gravitometric methods have proved to be of considerable promise.

Of these, the gravitometric, which depends on the measurement of small differences of the specific gravity of rocks of any particular area, has been known for the last 30 years. The instrument that has been developed for this purpose is the Eotvos Torsion Balance, and the

method is well adapted for the examination of flat, or but moderately undulating areas, where large massive mineral deposits or oil pools are likely to occur. During the last decade, it has been extensively and successfully used in prospecting for oil particularly in Persia, Burma, and in North America.

The magnetic method is naturally more useful in the case of magnetic ores, e.g., those of iron, than in other cases. The various electrical methods are practically all post-war developments. They depend on the fact that deposits of ores, oil, water, &c., cause slight differences in electrical conductivity to occur over the area containing them, and these differences can be indicated on a plot of the lines of force set up in an area by means of an electrical field. Electrical methods are not necessarily best suited for large deposits. The greater the difference of electrical conductivity of an ore deposit as compared with its surrounding rocks the more suitable the method becomes, and such a difference does not necessarily depend on the size of the deposit.

All the methods under discussion, whether they be based on variations in weight, in magnetism, or in electrical conductivity, do no more than indicate that differences exist. There is the possibility, of course, that the latter may be due to variations in the nature of the rocks themselves, and not necessarily to the presence of minerals. Hence the geophysical prospector is forced to lean on the geologist, and will probably always have to do so. In some cases the differences determined may be relatively so great that there is hardly much room for doubt as to the reason, but in other cases they may be slight. Again, all methods are operating at a disadvantage when used in areas where ore bodies occur only at considerable depths. The ideal conditions are large, massive deposits covered with a small amount of overburden only. In these cases the use of geophysical methods will undoubtedly save an immense amount of expensive prospecting; in less favourable cases they may merely indicate the most likely localities in which to bore, and in the least favourable where not to bore.

As to the costs involved, much depends on the nature of the work undertaken. If geological evidence warrants the close study of an area, it may be thoroughly surveyed by geophysical methods at a rate of about 1 square mile per month per single team of six men. For less thorough examinations and for a preliminary reconnaissance, ground can be covered much faster.

A feature of all the methods is the exceedingly small differences that have to be measured. As a result, extraordinarily sensitive instruments are required, and the interpretation of the results also becomes a complex matter. It cannot, therefore, be too strongly emphasized that those to whom is entrusted the task of putting these newer methods into practice must be scientists possessed of a very high class training indeed. Unfortunately, methods of geophysical prospecting are extremely liable to give quite erroneous indications if placed in the hands of unqualified operators, and for the same reason they are peculiarly open to chicanery.

In a country such as Australia, which is noted for the number and extent of its metalliferous means, it is obvious that an investigation of these newer methods of prospecting is an important matter. The Federal Government has accordingly decided to co-operate with the

British Government in an extensive and comprehensive test of the methods. The history of the negotiations that took place prior to this agreement being arrived at is given below.

At the request of the Council, Mr. H. W. Gepp, Chairman of Development and Migration Commission, who had previously taken a considerable interest in the matter, inquired into the whole position during his visit to Europe in the last two or three months of 1926. As a result, he put forward a scheme suggesting that the British and Australian Governments should co-operate financially in the application of geophysical methods in Australia; that, in the first place, the methods should be thoroughly tested on known areas in Australia; and that they might then be used in a systematic survey of others.

After preliminary inquiries had taken place as to the British authority which might appropriately co-operate, the matter was referred to the Empire Marketing Board. The latter, after obtaining favourable reports from its Research Committee, and from a strong technical sub-committee working under the Committee of Civil Research, agreed to co-operate with Australia in an exhaustive trial of all geophysical methods of possible Imperial importance (as distinct from a survey of Australian resources). The Board further agreed to provide £10,000 for the first year, and £6,000 for the second year on the condition that the Commonwealth Government contributed a like sum. This offer has been accepted by the Commonwealth.

The Australian contributions will be administered through the Council for Scientific and Industrial Research and the Development and Migration Commission. The actual trials will be carried out under the direction of Mr. A. Broughton Edge, an English consulting geologist, who has already had an extensive experience of prospecting by geophysical means. It is also intended that Australian University graduates will be trained in the methods, and arrangements are now being made to obtain the services of two such graduates, one for training, especially in gravitometrical methods, and the other in electrical methods.

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## Insect Pests of the Empire.

The Empire Marketing Board has made a grant of £5,000 per annum for five years, and of a capital sum of £15,000 to enable the work of the Imperial Bureau of Entomology to be extended. As a result, a "Parasite Laboratory" has been established at Farnham Royal, in Buckinghamshire, for the purpose of carrying out investigations on the biological control of weeds and insect pests. It has been estimated that not less than a tenth of the world's crops are destroyed annually by insect pests. It is stated that, in the tropics alone, this proportion must be increased to one-fifth, and it should be borne in mind that nearly one-half of the British Empire lies within the tropical zone. In Great Britain, it is estimated that the annual loss caused by insect pests amounts, on the average, to £30,000,000.

In the United States, the loss caused by the cotton boll-weevil alone has reached £40,000,000 in a year. Canada has to face an annual loss of £20,000,000 due to field crop pests, and, in addition, it is estimated that, from 1914 to 1921, the spruce-bud worm caused damage to the extent of £7,000,000 among spruce and fir trees. In Australia, the loss

from the sheep blowfly pest amounts to as much as £4,000,000 in a bad year; the cane grub takes annual toll of sugar-cane in Queensland to the extent of £100,000, while the direct and indirect loss through the cattle-tick pest has amounted to millions of pounds sterling since the introduction of the tick with Asiatic cattle from Batavia in about 1872.

In South Africa, enormous losses are caused by the codlin moth, which is stated to infest 20 per cent. of apples in normal years, and 40 per cent. in light crop years. In Egypt, the pink boll-worm caused damage, in 1921, amounting to £10,000,000; whilst in tropical America, north of the equator (including the West Indies), the damage done every year by sugar-cane moth borers reaches a total of £2,000,000 a year.

A preliminary programme of work to be carried out at the new Laboratory, at Farnham Royal, has been arranged as follows:—

(1) To ascertain the most effective European parasite of the codling moth, for this is likely to be of considerable value to the apple industry in Canada, Australia, New Zealand, South Africa, &c.

(2) The export of earwig parasites to Canada and New Zealand.

(3) To discover the natural enemies of the so-called lucerne flea (*Smynthurus viridis*), a common and unimportant insect in England, but one which has already hindered the growing of lucerne in some parts of South Australia, where it is beginning to spread.

(4) The export to Canada of parasites of *Lecanium capreæ*, a potential apple pest that has recently established itself in various parts of Canada.

(5) The transmission of the woolly aphis parasite (*Aphelinus mali*) to Kenya Colony.

(6) The sending of further consignments of the blowfly parasite (*Alysia manducator*) to Australia and New Zealand.

The Council considers that the question of entomological investigations in Australia, especially on methods of biological control, is of outstanding importance, and hopes to be able to proceed at an early date with the organization of an Entomological Section to take charge of the work.

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## Insect Pests of Australian Dried Fruit.

In the previous issue of the *Journal*, a short reference was made (page 19) to the visit to Australia of Dr. J. G. Myers, of the Imperial Bureau of Entomology. The funds for the visit were provided by the Empire Marketing Board and the Council in equal proportions. It was undertaken in order that an examination might be made of Australian dried fruit—currants and raisins—throughout all stages, from its production in Australia to its marketing in Great Britain, and particularly from the point of view of the possible total prevention of the small amount of infestation of the fruit by grubs, that now sometimes takes place.

Grub infestation of dried fruits is a problem of a world-wide nature, and is by no means limited to Australia. Unfortunately, a number of varieties of grubs propagated by moths are peculiarly adapted to a life

in dried fruits. The latter material is thus in danger of infestation from the time the fruit is dried in the producing areas until the time it is eventually consumed. Australian fruit found to be infested in other countries may quite possibly have left Australia in a clean condition, and have become infested in the countries of consumption. Fortunately, methods are slowly being evolved by which grubs may be combated, and not the least potent of these is a general dissemination among all consumers of the knowledge that certain varieties of moths can rapidly lay sufficient eggs to infest dried fruit badly if the latter is exposed for but a short time.

Dr. Myers has now furnished a report of his visit, and of the work he carried out in Great Britain at a subsequent date. Many of those engaged in the Australian dried fruit industry have introduced various processes, and have patented them. The various authorities concerned with the packing and export of the fruit also adopt different methods and regulations. All these are discussed by Dr. Myers. Briefly, he is of the opinion that regulations recently adopted have, in many instances, led to a marked lessening in insect infestation. In other cases, he points to the desirability of altering the regulations and conditions of packing in certain directions.

A summary of his report is as follows:—

1. By far the most important pest of Australian dried grape fruits is *Plodia interpunctella.*

2. Another moth and a beetle are fairly important, but attention should be concentrated on *Plodia,* since its elimination would nearly always involve that of the others.

3. The larvae of *Plodia* are neither "grubs" nor "maggots," but more correctly caterpillars.

4. *Plodia* lives on a wide variety of dried food products, and is nearly cosmopolitan in distribution.

5. By far the most important factor influencing the duration of the life-cycle in *Plodia* is temperature.

6. The cycle may vary from 31 days in the hottest part of the Australian summer to many months, if winter intervene.

7. *Plodia* is essentially now an indoor insect. It spreads but little by its own efforts.

8. There are probably two broods per year in Australia, but individual variation in development obscures these greatly.

9. Fruit shipped in late autumn or winter, and meeting hot weather in the tropics, will arrive in London in the same state with regard to "grubs" as that stored in Australia till the end of January.

10. *Ephestia cautella* is common in the raisin districts; but is attracted chiefly to unpacked fruit, whence it is largely eliminated by the stemmer and grader, so that it is almost negligible as a factor in the final London infestation.

11. *Silvanus surinamensis*—a small beetle—is, next to *Plodia,* the most abundant insect in Australian dried fruit, but it infests chiefly fruit which has been previously attacked by *Plodia and Ephestia,* or has been stored a long time.

12. At least so long as the present cleanliness regulations are enforced, drying-rack infestation by *Plodia* is commercially negligible.

13. The bulk of the infestation occurs after the fruit is packed.

## Cold Storage Problems—Report by Dr. F. Kidd and Dr. W. J. Young.

Dr. F. Kidd, of the Low Temperature Research Station, Cambridge. and Dr. W. J. Young, Associate Professor of Bio-chemistry, University of Melbourne, have completed their inquiries in South Africa and the Commonwealth, and have furnished a joint report to the Council outlining a scheme for the organization of investigations on cold storage problems, and dealing generally with the questions of equipment, personnel, and problems to be investigated. Research problems are considered under three main heads, viz., (i) economic research; (ii) technical research; and (iii) fundamental research. The most important recommendations relate to the following matters:—

1. As regards economic and technical research, it is recommended that the Council should explore the possibilities of promoting and assisting the formation of industrial research associations.

2. As regards meat problems, especially beef, it is recommended that a full scale experimental abattoir and a fully equipped biological, bacteriological, physical, and chemical laboratory should be established at one of the existing abattoirs to undertake investigations on problems connected with the transport, storage, and handling of meat.

3. As regards fruit, it is recommended that investigations be carried out on such matters as:—

(*a*) The reaction of fruits to temperature.
(*b*) Fungal diseases.
(*c*) Empirical storage trials for various methods of wrapping, sweating, sterilization, and packing.
(*d*) Behaviour of fruit in relation to exposure to air, sugar content, &c.

The importance of investigations on the production side is also emphasized, especially with respect to the improvement of yield by breeding, grafting, and by manurial and other soils treatments.

4. It is considered that at least four experimental stations would be necessary in order to meet the needs of the fruit industry in technical research.

5. It is recommended that a National Research Laboratory should be established by the Council for the purpose of carrying out fundamental research, and that provision for a tropical branch of this laboratory should be made at the proposed Tropical Agricultural Research Institute.

6. It is recommended that overseas transport investigations should be carried out by the Council in co-operation with the British Food Investigation Board.

7. It is recommended that immediate steps should be taken for the investigation of (i) bitter pit in apples; (ii) transport of chilled beef to Britain; (iii) overseas shipment of oranges; and (iv) Inter-State transport of bananas.

The question of the action to be taken for the initiation and development of investigations on cold storage problems is receiving the urgent attention of the Council in the light of the report furnished by Dr. Kidd and Dr. Young. A limited number of copies of the report are still available, and copies will be sent to persons specially interested on application to the Secretary of the Council.

## Appointment of Plant Pathologist—Dr. B. T. Dickson.

One of the earliest actions taken by the Council was the consideration of how to amplify the efforts already being made to cope with the many diseases that affect plants and crops of economic value in Australia. It was decided, *inter alia,* to appoint a senior officer to take charge of all activities of the Council in the field of plant pathology. After applications were called for throughout the world, Dr. B. T. Dickson, Professor of Plant Pathology in the McGill University, Canada, was appointed.

Dr. Dickson is a graduate of London University (B.Sc.), Queen's University, Ontario (B.A.), and Cornell University, United States of America (Ph.D.). He served in the Great War from 1916 to 1919, attaining the rank of captain. Originally in the Canadian Infantry, he was seconded to the First Army (British), and in 1918 was appointed Agricultural Officer on the Headquarters Staff. After the Armistice, he became commandant of the First Army, School of Agriculture, in France, until September, 1919, and for his services France created him a Chevalier de l'Ordre du Mérite Argicole. His research work has dealt chiefly with virus and other diseases in tobacco, tomato, raspberry, and other plants, as well as in floral and ornamental crops, such as snapdragon, peony, and chrysanthemums. He has also made extensive studies of oat smut and its control, and of rusts of oats and maize.

Dr. Dickson and his family were due to leave Vancouver per the s.s. *Niagara*, on 19th October, and are expected to arrive in Sydney on about the 10th November.

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## Ragwort—Possible Control by Biological Means.

At the present time, Mr. G. F. Hill, the Council's entomologist, is practically confining his investigations to a study of the underground grass grub which causes such serious damage to pastures in Tasmania. In the course of a search for possible parasites of the grub, he has visited several localities in the south-east portions of the mainland. In the course of these visits, and of those he has made to Tasmania, he has incidentally discovered three species of insects which infest ragwort (*Senecio jacobeae*), a poisonous weed, which is causing considerable concern among stock-owners in various parts of Australia.

These insects have not yet been scientifically identified, but they consist of the larvae of a small fly which tunnel in the leaves of ragwort, and the larvae of two species of moths which feed on the leaf stems, young shoots, and woody parts of the plant. Judging from a few preliminary experiments that have just been carried out, they are particularly destructive, as three or four caterpillars are capable of destroying young plants about 6 inches high in the course of not more than a week. In the locality in which they have been found, the insects are held in check by parasites, but it is thought to be highly probable that once established in ragwort infested areas, in which the parasites do not exist, they will play an important part in bringing the weed under control.

Prior to much further work being carried out on the insects, a survey is being made of the extent to which ragwort occurs in Australia, and of the localities in which it occurs. This latter work is being undertaken by the various State Committees of the Council.

## Visit to Australia of Dr. A. W. Hill, C.M.G., F.R.S.

The Empire Marketing Board has recently decided to make a grant of £4,000 per annum for a period of five years to the Royal Botanic Gardens, Kew. The grant will be devoted to two main purposes. In the first place, it will render possible the employment of an economic botanist who will be attached to the Royal Botanic Gardens, and who will be available either to visit the Dominions and Colonies from time to time, or to set free a superior officer of the Kew staff to undertake similar overseas missions. In the second place, the grant will enable botanical collectors to be sent to various parts of the world to study and to collect plants of economic importance for cultivation at Kew, and distribution to the Dominions and Colonies.

In order that effect may be given to the above proposals, Mr. H. C. Sampson, C.I.E., late Director of Agriculture, Madras, has been appointed to the Gardens, and this action has rendered it possible for the Director of the Gardens—Dr. A. W. Hill, C.M.G., F.R.S.—to undertake the first mission overseas.

Dr. Hill will leave England towards the end of October, and will come direct to Australia. He will reach Fremantle on the 29th November, and after spending a few days in Western Australia will come on east by the Transcontinental train. Approximately, seven weeks will be spent in Australia. New Zealand will also be visited, and the return home made via Java and the East Indies.

Dr. Hill will confer with the botanical authorities of every State of the Commonwealth. The various State Committees of the Council have already consulted their respective State authorities, and have furnished suggestions as to people and places Dr. Hill should see. These suggestions have been forwarded on to England where the final arrangements are being made.

It is expected that Dr. Hill will be present at the meetings of the Australasian Association for the Advancement of Science, to be held in Tasmania in January, 1928.

## Publications of the Council.

It has been decided that, in future, the publications issued by the Council will be of three main types. The former bulletin series will be continued, and will be confined to the results of completed researches. Secondly, the issue of pamphlets will be continued, and they will relate to matters of lesser importance than those published in bulletins. They may also consist of compilations. Thirdly, there will be papers published in the *Quarterly Journal* relating to incompleted investigations, to matters of general interest, &c. It has also been decided that officers of the Council may, with the approval of the Council, publish papers in other journals.

The series of circulars issued by the former Institute of Science and Industry will be discontinued.

By Authority: H. J. Green, Government Printer, Melbourne.